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UNITED STATES

COAST AND GEODETIC SURVEY

T. C. MENDENHALL

SUPERINTENDENT

HYPSONOMETRY

HEIGHTS FROM GEODETIC LEVELING

BETWEEN

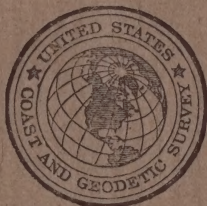
OKOLONA, MISS., AND ODIN, ILL.

1885 and 1888-1890

Report by CHARLES A. SCHOTT, Assistant
and Chief of the Computing Division

Fieldwork by J. B. WEIR, Assistant; ISAAC WINSTON and
P. A. WELKER, Subassistants, and F. A. YOUNG, Aid

APPENDIX No. 3—REPORT FOR 1892



WASHINGTON

GOVERNMENT PRINTING OFFICE

1893

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APPENDIX No. 3—1892.

ON THE RESULTS OF SPIRIT LEVELING OF PRECISION BETWEEN OKOLONA, MISS., AND ODIN, ILL., FROM OBSERVATIONS MADE BY J. B. WEIR, ASSISTANT; ISAAC WINSTON AND P. A. WELKER, SUBASSISTANTS, AND F. A. YOUNG, AID.

A report by CHARLES A. SCHOTT, Assistant, and Chief of the Computing Division.
Submitted for publication December 20, 1892.

I have the honor to submit herewith a report on the results of spirit leveling of precision between Okolona, Miss., and Odin, Ill. This is in continuation of the exact leveling between the Gulf of Mexico (at Biloxi and Mobile) and St. Louis, Mo. The latter place is reached from Odin by the levels along the the thirty-ninth parallel. Respecting the starting point, Okolona, see my report of September 28, 1888, and for Odin and St. Louis, see Appendix No. 8, C. and G. S. Rep. for 1882, p. 555.

Route line.—From Okolona the line follows the Mobile and Ohio Railroad to Corinth, Miss., and Jackson, Tenn.; thence by the Illinois Central Railroad to Cairo, Ill., and Villa Ridge, Ill. (close to it); from here it continues by the same road to Odin, Ill.; thence to St. Louis, Mo., along the Ohio and Mississippi Railroad. See accompanying diagram (illustration No. 19).

The distances are as follows:

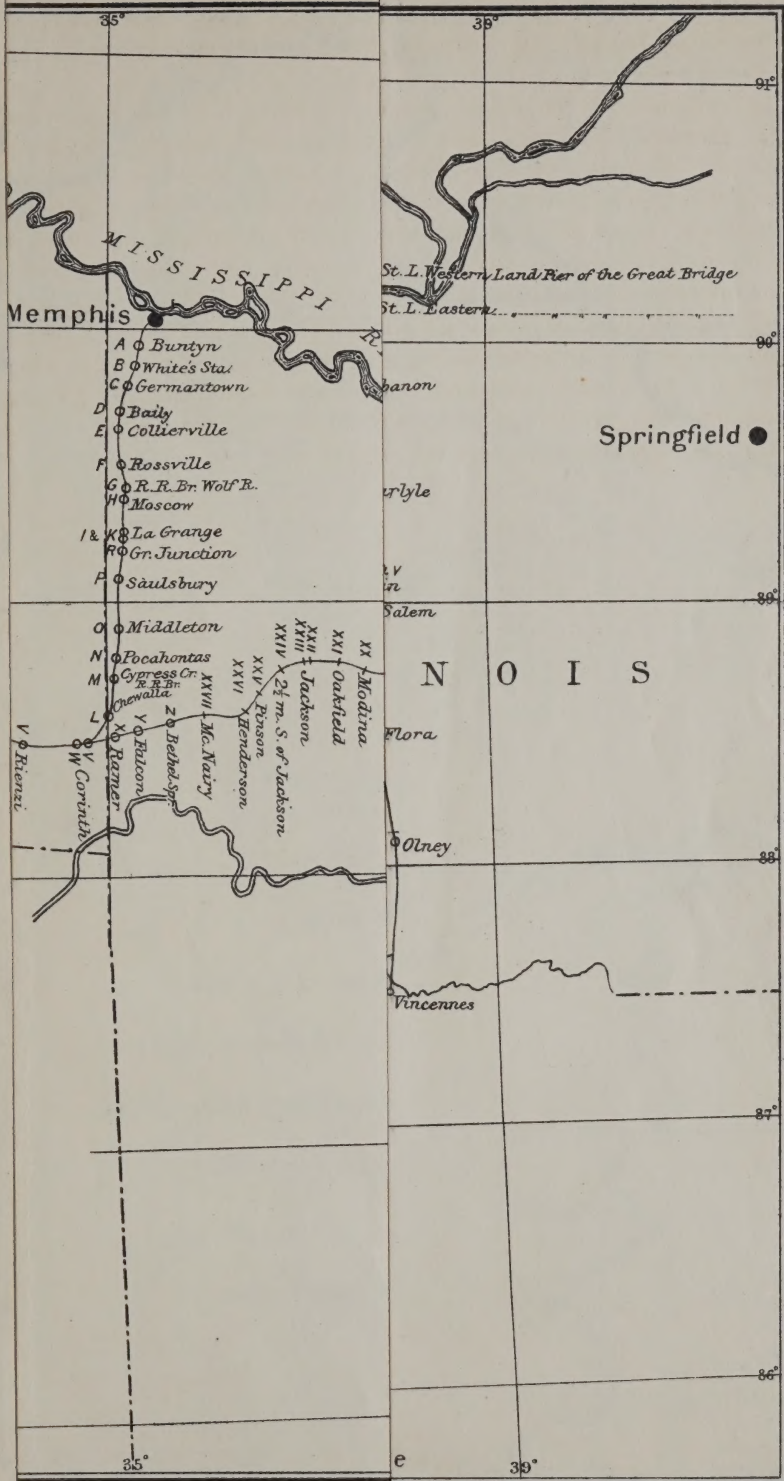
Biloxi (Tidal mark) to Mobile (A)	94.3 km. or	58.6 st. miles.
Mobile (A) to Okolona (K)	423.5	263.1
Okolona (K) to Greenfield (XV)	265.4	164.9
Greenfield (XV) to Villa Ridge (Z ₂)	128.1	79.6
Villa Ridge (Z ₂) to Odin (M ₃ or V)	176.0	109.4
Total from Biloxi to Odin,	1 087.3	675.6

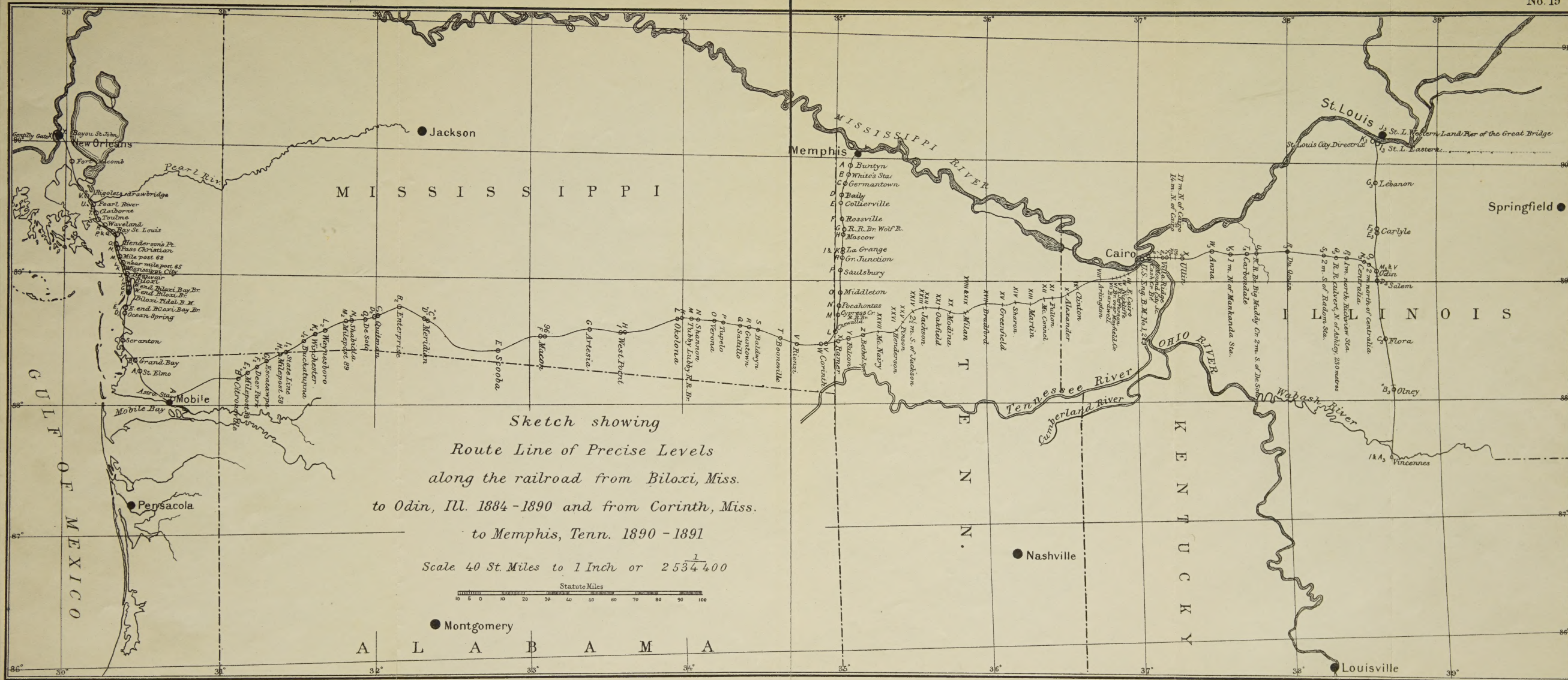
Observers and dates.—Section I, from Okolona, Miss., to Jackson, Tenn.: forward measure by Subassistant J. Winston, backward measure by Mr. F. A. Young, and from Jackson, Tenn., to Greenfield, Tenn., backward by Winston and forward by Young; between October, 1889, and March, 1890. Section II, from Greenfield to Villa Ridge, Ill.: forward and backward measures by Subassistants Winston and P. A.

Welker, between October, 1888, and January, 1889. Section III, from Villa Ridge to Odin, Ill., between April and June, 1885, Assistant J. B. Weir, observer.

Instruments and method of observing.—Section I was run independently forward and backward, the observers changing direction at Jackson. Winston used geodetic micrometer level No. 5 and Young used No. 6; these levels were made at the Survey Office in 1888. Section II was run twice, independently, once forward and once backward, the observers changing directions frequently; the observers used geodetic micrometer levels No. 2 and No. 3. Section III was the last line run by the old method of two parallel and simultaneous lines, alternate stretches (of 5 to 10 miles) being run in opposite directions; micrometer level No. 1 was employed. The rods were generally 200 metres apart, with the instrument mounted midway between them.

The instrumental constants are as follows:





Spirit leveling instruments	No. 1.	No. 2.	No. 3.	No. 5.	No. 6.
Aperture of telescope	3.5 ^{cm}	4.3 ^{cm}	4.3 ^{cm}	2.9 ^{cm}	2.9 ^{cm}
Focal length of telescope	40.7 ^{cm}	41.0 ^{cm}	41.0 ^{cm}	34.8 ^{cm}	34.8 ^{cm}
Magnifying power of telescope	26	24	25	28	28
Low-power eyepiece inserted		Sept., 1887	Sept., 1887		
Value of 1 division of striding level when determined	{ 5.60 " 5.79 July 23, 1883 Nov. 21, 1885	{ 3.37 " 3.37 Apr. 2, 1887	{ 2.73 " 2.73 June 2, 1887	{ 2.11 " 2.08 Sept. 26, 1888 Apr. 8, 1890	{ 2.44 " 2.53 May 23, 1888 Apr. 8, 1890
Inequality of collars ($\alpha \pm$ sign larger smaller) indicates object end when determined	{ -2.47 " -1.17 Apr. 4, 1885 June 12, 25, 1885	{ +0.12 " (+0.2) +0.28 Oct. 4, 1888 Dec. 8, 1888	{ -0.11 " (+0.1) +0.22 Oct. 11, 1888 Dec. 12, 1888	{ -0.25 " (-0.42) -0.48 July 24, 1889 Mar. 5, 1890	{ +0.18 " (+0.10) +0.07 Aug. 10, 1889 Mar. 15, 1890
Value of 100 div. of micrometer screw when determined	443.1 Aug. and Sept., 1877	257.5* Apr., 1887	257.5* June, 1880	{ 313.1 " 311.6 Sept. 19, 22, 1888 July 22, 23, 1889	{ 310.6 " 312.0 June 24, 25, 1889 July 22, 23, 1889
Angular value of telescope threads when determined	17 01.0 Nov. 17, 1884	16 39.3 Jan. 19, 1887	14 00.7 Jan. 19, 1887	18 58.5 July 22, 1889	18 50.6 July 22, 1889
Index corrections to metric rods † (projection beyond zero line)	E 62.4 F 59.9	C 60.0 61.2 (60.6)	D 59.8 61.2 (60.5)	L { 0.0 -0.5 M { 0.0 -0.5	N { 0.0 -0.5 O { 0.0 -0.5
Temperature of rod when of standard length	16.7°C 18.9°C	20.3°C	14.4°C	21.7°C 21.7	21.7°C 21.7
Correction, when determined	June 5, 1885	Oct. 4, 1888 Jan. 5, 1889	Oct. 4, 1888 Jan. 5, 1889	July 23, 1889 Mar. 14, 1890	July 23, 1889 Mar. 14, 1890

* See Appendix No. 14, C. and G., Survey Report for 1887.

† Previous to 1889 the graduated brass rod supporting the sliding target was fastened to the wooden rod only at its middle part, allowing expansion and contraction of the scale-up as well as down; at the bottom of the rod there was sufficient space left to permit of the expected expansion under high temperature. The index correction became thus large and variable. In July, 1889, this construction was changed, the brass scale and wooden rod were screwed fast at their bottom ends and the former was bent under the latter and in close connection with the contact knob which stands for the zero of the graduation; hence, there is no index correction to begin with, but wear will produce a small negative one.

Instruments Nos. 5 and 6 are of the same pattern as No. 1; see plate No. 46 in C. and G. Survey Report for 1880. Coefficient of expansion of brass scale of rods 0.000018 for centigrade scale.

A description of the permanent bench marks is appended to this report.

Computation and results.—Field computations were made by the respective observers; the second or independent office computation were made by the following computers under the general supervision of Mr. L. A. Bauer, viz: Section I by Subassistant J. Nelson, aided by A. Bonnot, J. B. Boutelle, and H. F. Flynn (October, 1892); Section II by F. A. Young, while temporarily attached to the computing Division, aided by J. Page; Section III by F. M. Little (September, 1888). Special tables of corrections for curvature, refraction, collar inequality, and temperature were constructed for each instrument to facilitate their application. The two computations were collated and the final results are as follows:

Results of geodetic spirit leveling in Mississippi, Tennessee, Kentucky, and Illinois, 1885-'90.

SECTION I.—FROM OKOLONA, MISS., TO GREENFIELD, TENN., OCTOBER, 1889, TO MARCH, 1890.

Date.	Benchmark.		Distance.		Difference of height between marks.			Discrepancy.		Height of mark above average Gulf level at Biloxi, Miss.
	From—	To—	Between successive marks.	From initial mark.	Direction of measure.		Mean.	Total.		
					Forward (northward).	Backward (southward).				
			km.	km.	m.	m.	m.	F-B	Accumulated.	
1889-'90.										
Dec.										
4	K	K	0.058	0.000	-1.5472				m.	
4	K	L	0.921	0.058	-5.9169				+94.6137†	
4	52	52	1.074	0.921	-4.7158	-5.9164	5.9166	-0.5	+93.0665†	
4	53	53	1.995	1.995	*-4.7107	-4.7107	-4.7132	-5.1	83.9839	
4, 7, 6,	53	54	1.075	3.070	*-3.8072	*-3.8043	-3.8058	-2.9	80.1781	
4	54	55	1.054	4.124	-1.7082	-1.7080	-1.7081	-0.2	78.4700	
4	55	56	1.080	5.204	-0.7046	-0.7071	-0.7059	+2.5	77.7641	
4	56	57	1.166	6.370	-0.4843	-0.4828	-0.4836	-1.5	77.2805	
4	57	58	1.347	7.717	+4.0848	+4.0890	+4.0869	-4.2	81.3674	
4, 5, 5,	58	M	0.832	8.549	-5.3555	-5.3586	-5.3570	+3.1	76.0104	
5	59	60	1.100	9.649	*-3.5479	*-3.5458	+3.5458	+4.2	79.5562	
5	M	59	9.649	10.871	*-3.0834	*-3.0874	-3.0854	+4.0	76.4708	
5, 9, 13,	59	61	1.222	12.141	*-3.7395	*-3.7444	-3.7420	+4.9	72.7288	
12, 13	60	61	1.270	12.141	*+1.8380	*+1.8340	+1.8360	+4.0	74.5648	
12, 13	61	62	0.801	12.942						
12, 13	62	62	0.084	13.026	+2.5265	+2.5270	+2.5268	-0.5	+77.0916	
12	62	N	0.084	13.026						
9	62	63	1.253	14.195	+2.2186	+2.2183	+2.2184	+0.3	76.7832	
12	63	64	1.238	15.433	-2.0445	-2.0433	-2.0439	-1.2	74.1393	
12	64	65	1.283	16.716	-2.4139	-2.4083	-2.4111	+5.6	76.5504	
11	65	66	1.287	18.003	*+3.4014	*+3.4008	+3.4011	+0.6	79.9515	
11, 14	65	67	1.290	19.293	*+4.6888	*+4.6816	+4.6852	+7.2	84.6307	
9, 10, 14,	66									
11, 14	66									

† Taken from Appendix No. 20, C. and G. Survey Report for 1888, p. 422.

* An asterisk attached to any number indicates that it is a mean value of two determinations; a double asterisk denotes a mean of three or more values.

Results of geodetic spirit leveling in Mississippi, Tennessee, Kentucky, and Illinois, 1885-'90.

SECTION I.—FROM OKOLONA, MISS., TO GREENFIELD, TENN., OCTOBER, 1889, TO MARCH, 1890.

Date.	Benchmark.		Distance.		Difference of height between marks.		Discrepancy.		Height of mark above average Gulf level at Biloxi, Miss.
	From—	To—	Between successive marks.	From initial mark.	Direction of measure.		Partial.	Total.	
					Forward (northward).	Backward (southward).			
1889-'90. Dec. 10 10, 14 14	67 68	68 69	km. 1.282 1.104	km. 20.575 21.679	m. +1.6234 *+5.8742	m. +1.6248 *+5.8796	mm. -1.4 -5.4	mm. +19.4 +14.0	m. 86.2608 92.1377
	69	0	0.169	21.848	+3.9708	+3.9707	+0.1	+14.1	+96.1085
	69	70	1.295	22.974	+4.7445	+4.7477	-3.2	+10.8	96.8838
	70	71	1.289	24.263	*-7.3977	*-7.3967	-1.0	+9.8	89.4866
	71	72	1.265	25.528	*-7.3938	*-7.3922	-3.1	+6.7	82.0944
	72	73	1.312	26.840	*-3.6463	*-3.6376	-8.7	-2.0	78.4524
	73	74	1.313	28.153	+2.0135	+2.0100	+3.5	+1.5	80.4642
	74	75	0.765	28.918	+2.5369	+2.5380	-1.1	+0.4	83.0016
	16	75	P	29.062	+1.9040	+1.9040	0.0	+0.4	+84.9056
16 17, 20 16, 20 16 16, 20 23 23 20 20 20 20 20, 21 21, 28	75 76	76 77	1.196 1.204	30.114 31.318	-2.1084 *+0.4379	-2.1057 *+0.4416	-2.7 -3.7	-2.3 -6.0	80.8946 81.3344
	77	78	1.068	32.386	-0.9050	-0.9030	-2.0	-8.0	80.4304
	78	79	1.296	33.682	+1.3687	+1.3723	-3.6	-11.6	81.8009
	79	80	1.017	34.699	*+0.6890	*+0.6929	-3.9	-15.5	82.4919
	80	81	0.917	35.616	+0.6953	+0.6992	-3.9	-19.4	83.1891
	81	82	0.923	36.539	+0.5114	+0.5175	-6.1	-25.5	83.7035
	82	83	0.968	37.507	+1.9064	+1.8993	+7.1	-18.4	85.0663
	83	84	0.976	38.483	+1.5304	+1.5336	+3.2	-21.6	87.1383
	84	85	1.014	39.497	*+1.0296	*+1.0258	+3.8	-17.8	88.1660

21	21	85	86	1.000	40.497	+1.9659	+1.9614	+1.9636	+4.5	—13.3	90.1296
21	27	86	87	0.944	41.441	+1.2753	+1.2745	+1.2749	+0.8	—12.5	91.4045
21	27	87	88	0.987	42.428	+3.5592	+3.5562	+3.5577	+3.0	—9.5	94.9622
27	27	88	Q	0.072	42.500	+0.5042	+0.5042	+0.5042	0.0	—9.5	+95.4664
24, 28	27, 28, 30	88	89	1.340	43.768	**+0.7279	**+0.7334	+0.7306	—5.5	—15.0	95.6928
24	26, 27	89	90	1.321	45.089	+2.1319	+2.1293	+2.1306	+2.6	—12.4	97.8234
24	26	90	91	1.229	46.318	+3.1698	+3.1686	+3.1692	+1.2	—11.2	100.9926
24	26	91	92	1.160	47.478	+5.2630	+5.2630	+5.2630	+0.7	—10.5	106.2556
24	26	92	93	1.123	48.601	+0.6343	+0.6371	+0.6357	—2.8	—13.3	106.8013
24	26	93	94	1.166	49.767	*+7.5660	*+7.5636	+7.5618	—3.6	—16.9	114.4531
24	24	94	R	0.259	50.026	+6.9860	+6.9848	+6.9854	+1.2	—15.7	+121.4385
30	Dec. 26{ Jan. 4}	94	95	0.985	50.752	—0.7006	—0.6963	—0.6984	—4.3	—21.2	113.7547
30, J. 4,	Jan. 4	95	96	1.015	51.767	*—5.9547	*—5.9554	—5.9548	+1.2	—20.0	107.7999
30, J. 4,	Jan. 3, 4	96	97	1.020	52.787	*—5.0448	*—5.0415	—5.0432	—3.3	—23.3	102.7507
31	3	97	98	1.012	53.799	—0.7431	—0.7449	—0.7440	+1.8	—21.5	102.0127
31	3	98	99	1.014	54.813	—1.0366	—1.0392	—1.0379	+2.6	—18.9	100.9748
31	3	99	100	1.032	55.845	+1.3272	+1.3230	+1.3251	+4.2	—14.7	102.2999
Dec.	Jan.	100	101	1.042	56.887	+7.8915	+7.8930	+7.8922	—1.5	—16.2	110.1021
31	3	101	102	1.247	58.134	+3.4788	+3.4736	+3.4762	+5.2	—11.0	113.6683
J. 8	8	102	S	0.156	58.290	+0.5366	+0.5362	+0.5364	+0.4	—10.6	+114.2047
D. 31	3	102	103	1.005	59.139	—6.2119	—6.2150	—6.2134	+3.1	—7.9	107.4549
D. 31	2	103	104	0.996	60.135	—3.8562	—3.8564	—3.8563	+0.2	—7.7	103.5986
D. 31	7	104	105	1.001	61.136	+0.7974	+0.7998	+0.7986	—2.4	—10.1	104.3972
D. 31, J. 7	6	105	106	1.725	62.861	—0.5222	—0.5227	—0.5224	+0.5	—9.6	103.8748
7	6	106	107	1.230	64.091	+0.8983	+0.8981	+0.8982	+0.2	—9.4	104.7730
7, 8	6, 8	107	108	1.101	65.192	*+0.3100	*+0.3146	+0.3123	—4.6	—14.0	105.0853
7	6	108	109	1.226	66.418	+3.6314	+3.6375	+3.6344	—6.1	—20.1	108.7197
7	6	109	110	0.781	67.199	—0.3184	—0.3160	—0.3172	—2.4	—22.5	108.4625

* An asterisk attached to any number indicates that it is a mean value of two determinations; a double asterisk denotes a mean of three or four values.

17	22	129	130	1'169	89'400	—0'9090	—0'9105	+0'9098	+1'5	—57'7	132'8379
23	23	130	U	0'254	89'654	+5'7252	+5'7284	+5'7268	—3'2	—60'9	+138'5647
17, 18	22	130	131	0'973	90'373	—3'1784	—3'1839	—3'1812	+5'5	—52'2	129'6567
18	22	131	132	1'000	91'373	—1'0759	—1'0756	—1'0758	—0'3	—52'5	128'5809
18	22	132	133	1'033	92'406	—0'9033	—0'9087	—0'9060	+5'4	—47'1	127'6749
18	21	133	134	0'973	93'379	+0'1574	+0'1579	+0'1576	—0'5	—47'6	127'8325
18	21	134	135	0'984	94'363	+0'0889	+0'0874	+0'0882	+1'5	—46'1	127'0207
18	21	135	136	0'990	95'353	+0'1058	+0'1088	+0'1073	+3'0	—43'1	126'8134
18	21	136	137	1'005	96'458	+0'0470	+0'0423	+0'0446	—4'7	—47'8	126'7688
18, 23	21, 23	137	138	0'717	97'175	*+0'0040	*+0'0028	+0'0034	+1'2	—46'6	126'7722
18	20	138	139	0'954	98'129	+0'1358	+0'1386	+0'1372	+2'8	—43'8	126'6350
23	20	139	140	1'110	99'239	+1'3019	+1'3017	+1'3018	+0'2	—43'6	127'9368
24	20	140	141	1'288	100'527	+2'9675	+2'9705	+2'9690	—3'0	—46'6	130'9058
24	27	141	142	1'130	101'657	+2'7087	+2'7133	+2'7110	—4'6	—51'2	133'6108
24	25, 27	142	143	1'073	102'730	+3'8868	+3'8914	+3'8891	—4'6	—55'8	137'5059
24	25	143	144	1'081	103'811	+1'8698	+1'8751	+1'8724	—5'3	—61'1	139'3783
24	25	144	145	1'182	104'993	—6'8448	—6'8457	—6'8452	+0'9	—60'2	132'5331
24	25	145	146	0'999	105'992	—3'6295	—3'6303	—3'6299	+0'8	—59'4	128'9032
24	25	146	147	0'996	106'988	+0'9565	+0'9526	+0'9546	+3'9	—55'5	129'8578
24, 27	25	147	148	1'079	108'067	+0'3593	+0'3497	+0'3500	+0'6	—54'9	130'2078
27	25	148	149	1'005	109'072	+2'0512	+2'0550	+2'0551	—3'8	—58'7	132'2609
31	31	149	V	0'384	109'456	+4'9679	+4'9664	+4'9672	+1'5	—57'2	+137'2281
31	31	V	W	0'041	109'497	+0'0568	+0'0567	+0'0568	+0'1	—57'1	+137'2849
27	25, 31	149	150	0'968	110'040	+1'9026	+1'9078	+1'9052	—5'2	—63'9	134'1661
27, 28	31	150	151	0'990	111'030	+2'1269	+2'1323	+2'1296	—5'4	—69'3	136'2957
28, 31	1, 3	151	152	0'994	112'024	*+1'8222	**+1'8268	+1'8245	—4'6	—73'9	138'1202
28, 31	30, 31	152	153	0'976	113'000	*+2'4148	*+2'4192	+2'4170	—4'4	—78'3	140'5372
31	31	153	154	0'973	113'973	+4'1856	+4'1878	+4'1867	—2'2	—80'5	144'7239
28	30	154	155	1'260	115'233	+6'5800	+6'5941	+6'5916	—5'1	—85'6	151'3155
28	30	155	156	1'265	116'498	—1'3306	—1'3304	—1'3300	+0'8	—84'8	149'9855
28, F. I	30, F. I	156	157	1'272	117'770	*—7'4133	*—7'4098	—7'4116	—3'5	—88'3	142'5739
28, F. I	30, F. I	157	158	0'985	118'755	*—5'4414	*—5'4346	—5'4380	—6'8	—95'1	137'1359

* An asterisk attached to any number indicates that it is a mean value of two determinations; a double asterisk denotes a mean of three or more values.

Results of geodetic spirit leveling in Mississippi, Tennessee, Kentucky, and Illinois, 1885-90.

SECTION I.—FROM OKOLONA, MISS., TO GREENFIELD, TENN., OCTOBER, 1889, TO MARCH, 1890.

Date.	Benchmark.		Distance.		Difference of height between marks.		Discrepancy.		Height of mark above average Gulf level at Biloxi, Miss.
	From—	To—	Between successive marks.	From initial mark.	Direction of measure.	Mean.	Partial.	Total.	
					Forward (northward).	Backward (southward).	F-B	Accumulated.	
1889-'90. Jan.									
28	158	159	km. 1'164	km. 119'919	m. -3'1102	m. -3'1112	mm. +1'0	mm. -94'1	m. 134'0252
29, F. 1	159	160	1'182	121'101	* -2'0511	* -2'0458	5'3	99'4	131'9768
F. 3	160	161	1'153	122'254	+0'2026	+0'2032	-2'6	-102'0	132'1807
3	161	162	1'126	123'380	* -5'9732	* -5'9765	+3'3	-98'7	126'2059
3	162	163	1'257	124'637	-1'5643	-1'5676	+3'3	-95'4	124'6399
3	163	164	0'958	125'595	+0'4410	+0'4423	-1'3	-96'7	125'0815
3	164	165	0'964	126'559	+0'9545	+0'9535	+1'0	-95'7	126'0355
3	165	166	0'903	127'462	-1'2348	-1'2359	+1'1	-94'6	124'8001
6	166	167	0'360	127'822	-0'0722	-0'0733	+1'1	-93'5	124'7273
6	167	X	0'302	128'124	+1'2938	+1'2937	+0'1	-93'4	+126'0211
6	167	168	1'187	129'009	* -0'2015	* -0'1968	-4'7	-98'2	124'5281
6, 8, 13	168	169	0'992	130'001	** -0'2102	** -0'2073	-2'9	-101'1	124'3193
6, 8, 13	169	170	1'306	131'307	** +0'5630	** +0'5695	-6'5	-107'6	124'8855
6, 8, 13	170	171	1'048	132'355	* +0'6272	* +0'6328	-5'6	-113'2	125'5155
8	171	172	1'305	133'600	+2'2270	+2'2312	-4'2	-117'4	127'7446
8, 13	172	173	1'143	134'803	* +0'7940	* +0'7888	+5'2	-112'2	128'5360
8, 14	173	174	1'090	135'893	* +0'7816	* +0'7783	+3'3	-108'9	129'3160
8, 10	174	175	0'935	136'828	+0'5154	+0'5137	+1'7	-107'2	129'8306
14	175	Y	0'042	136'870	+1'4754	+1'4752	+0'2	-107'0	+131'3059

10	11, 12	175	176	0.971	137.799	+1.1858	+1.1898	+1.1878	-4.0	-111.2	131.0184
10	11, 14	176	177	0.974	138.773	* +0.8127	* +0.8152	+0.8140	-2.5	-113.7	131.8324
10	11	177	178	1.341	140.114	+0.9444	+0.9422	+0.9433	+2.2	-111.5	132.7757
10	11	178	179	1.172	141.286	+0.3799	+0.3746	+0.3772	+5.3	-106.2	133.1529
10	11, 14	179	180	1.061	142.347	* +0.9102	* +0.9155	+0.9128	+5.3	-111.5	135.0657
10	15	180	181	1.076	143.423	+0.8231	+0.8243	+0.8237	-1.2	-112.7	135.8894
10	15	181	182	1.138	144.561	+0.4572	+0.4524	+0.4548	+4.8	-107.9	136.3442
10	15	182	183	0.975	145.536	+0.2146	+0.2118	+0.2132	+2.8	-105.1	136.5574
10, 14	15	183	184	0.987	146.523	+0.0176	+0.0134	+0.0155	+4.2	-100.9	136.5729
14	15	184	185	0.926	147.449	+2.7822	+2.7802	+2.7812	+2.0	-98.9	139.3541
20	20	185	Z	0.062	147.511	+2.9278	+2.9280	+2.9279	-0.2	-99.1	+142.2820
14, 15, 20	20	185	186	0.991	148.440	* +1.3787	* +1.3785	+1.3786	+0.2	-98.7	140.7327
15	20	186	187	0.961	149.401	+1.8633	+1.8601	+1.8617	+3.2	-95.5	142.5944
15, 17	19, 20	187	188	0.957	150.358	+2.2057	+2.2005	+2.2061	-0.8	-96.3	144.8005
17	19	188	189	0.970	151.328	+2.9576	+2.9576	+2.9576	0.0	-96.3	147.7581
17, 21	19, 21	189	190	0.965	152.293	* +5.3928	* +5.3976	+5.3952	-4.8	-101.1	153.1533
17	19	190	191	0.957	153.250	-2.1143	-2.1107	-2.1125	-3.6	-104.7	151.0408
17	19	191	192	0.948	154.198	-5.3693	-5.3664	-5.3678	-2.9	-107.6	145.6730
17, 21, 26	19, 21, 26	192	193	1.190	155.388	** -6.7367	** -6.7314	-6.7340	-5.3	-112.9	138.9390
17, 21, 26	19, 21, 26	193	194	1.572	156.960	** -1.6523	** -1.6452	-1.6468	-7.1	-120.0	137.2902
18	18	194	XXVII	0.105	157.065	+1.7863	+1.7866	+1.7864	-0.3	-120.3	+139.0766
17	18	194	195	1.291	158.251	-3.1713	-3.1683	-3.1698	-3.0	-123.0	134.1204
17	18	195	196	0.967	159.218	+1.2685	+1.2646	+1.2666	-3.9	-126.9	132.8538
17, 22 } 25, 26 }	18, 25	196	197	0.971	160.189	* -1.3256	* -1.3196	-1.3226	-6.0	-132.9	131.5312
22, 26	18, 25, 26	197	198	0.995	161.184	** -1.1027	** -1.0954	-1.0990	-7.3	-140.2	130.4322
22	18	198	199	1.115	162.299	+0.1508	+0.1553	+0.1530	-4.5	-144.7	130.5852
22	18	199	200	1.008	163.307	-1.4508	-1.4505	-1.4506	-0.3	-145.0	129.1346
22	25	200	201	1.158	164.465	-0.8289	-0.8304	-0.8296	+1.5	-143.5	128.3050
22	25	201	202	1.159	165.624	-1.8641	-1.8633	-1.8637	-0.8	-144.3	126.4413
22	24	202	203	1.150	166.774	-0.9547	-0.9539	-0.9543	-0.8	-145.1	125.4870
22	24	203	204	1.156	167.930	-0.0736	-0.0751	-0.0744	+1.5	-143.6	125.4126
22, 28	24, 28	204	205	1.140	169.070	* -2.4561	* -2.4604	-2.4582	+4.3	-139.3	122.9544
22	24	205	206	1.143	170.213	-1.1269	-1.1318	-1.1294	+4.9	-134.4	121.8250

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Results of geodetic spirit leveling in Mississippi, Tennessee, Kentucky, and Illinois, 1885-90.

SECTION I.—FROM OKOLONA, MISS., TO GREENFIELD, TENN., OCTOBER, 1889, TO MARCH, 1890.

Date.	Benchmark		Distance		Difference of height between marks.		Discrepancy.		Height of mark above average Gulf level at Biloxi, Miss.
	From—	To—	Between successive marks.	From initial mark.	Direction of measure.		Partial.	Total.	
					Forward (northward).	Backward (southward).			
1889-'90. Jan.									
22	206	207	km. 1'166	km. 171'379	m. —0'7595	m. —0'7583	mm. —1'2	mm. —135'6	m. 121'0661
22, 28	207	208	1'014	172'393	—0'0244	* —0'0239	—0'5	—136'1	121'0419
28, M. 3	208	209	1'026	173'419	* +7'5460	* +7'5496	—3'6	—139'7	128'5897
M. 1	209	XXVI	0'055	173'474	+2'3755	+2'3756	—0'1	—139'8	+139'9653
28, M. 3	209	210	0'761	174'180	* +4'0981	* +4'1014	—3'3	—143'0	132'6895
28	210	211	0'928	175'108	—5'2792	—5'2756	—3'6	—146'6	127'4121
28, M. 3	211	212	0'941	176'049	* —3'8215	* —3'8272	+5'7	—140'9	123'5877
28, M. 3	212	213	0'944	176'993	* —2'8571	* —2'8424	+5'3	—135'6	120'7479
28, M. 3	213	214	1'130	178'123	* —2'2343	* —2'2349	+0'6	—135'0	118'5133
28, M. 4	214	215	0'804	178'927	—3'0059	—3'0089	+3'0	—132'0	115'5059
4, 7	215	216	0'965	179'892	* —0'0145	* —0'0160	+1'5	—130'5	115'4907
4	216	217	1'270	181'162	+1'9980	+1'9928	+5'2	—125'3	117'4861
4	217	218	1'272	182'434	—1'6141	—1'6094	—4'7	—130'0	115'8743
4	218	219	0'392	182'826	—0'2619	—0'2619	0'0	—130'0	115'6124
5	219	XXV	0'065	182'891	+1'8802	+1'8805	—0'3	—130'3	+117'4928
4	219	220	1'290	184'116	—0'9765	—0'9815	+5'0	—125'0	114'6334
6	220	221	0'950	185'066	+1'1314	+1'1358	—4'4	—129'4	115'7670
4	221	222	1'130	186'196	—2'2181	—2'2189	+0'8	—128'6	113'5485
4	222	223	1'116	187'312	—0'2805	—0'2809	+0'4	—128'2	113'2678

4	6	223	1'130	188.442	— 0.9523	— 0.9577	— 0.9550	+5.4	—122.8	112.3128
8	6, 11	224	1'146	189.588	+ 0.6578	+ 0.6584	+ 0.6581	+0.6	—123.4	112.9709
8, 12	11, 12	225	1'156	190.744	* — 0.9324	* — 0.9266	— 0.9295	—5.8	—129.2	112.0414
8, 12	11, 12	226	1'143	191.887	* + 0.1016	* + 0.1090	+ 0.1053	—7.4	—136.6	112.1467
8	11	227	1'159	193.046	— 0.7416	— 0.7419	— 0.7418	+0.3	—136.3	111.4049
8	10	228	1'271	194.317	— 3.2715	— 3.2732	— 3.2724	+1.7	—134.6	108.1325
8	10	229	0.956	195.273	— 0.8452	— 0.8456	— 0.8454	+0.4	—134.2	107.2871
8, 12	231	230	0.960	196.233	— 0.3909	— 0.3953	— 0.3931	+4.4	—129.8	106.8940
12, 13	10, 13	XXIV	1'041	197.274	* + 0.2519	* + 0.2556	+ 0.2538	—3.7	—133.5	107.1478
12	10	232	0.831	198.105	— 0.3639	— 0.3617	— 0.3628	—2.2	—135.7	106.7850
13	10	233	1'045	199.150	+ 6.6109	+ 6.6250	+ 6.6224	—5.1	—140.8	113.4074
13, 14	10, 13, 14	234	1'056	200.206	** + 9.3970	** + 9.3977	+ 9.3984	—2.7	—143.5	122.8038
13	10	XXIII	0.776	200.982	— 2.5679	— 2.5675	— 2.5677	—0.4	—143.9	120.2381
1889,	Nov.	XXII	0.342	201.324	— 0.9770	— 0.9772	— 0.9771	+0.2	—143.7	119.2610
27	27	XXII	1'478	202.802	+ 14.6219	+ 14.6234	+ 14.6226	—1.5	—145.2	133.8836
27, 29	26, 27	51	1'541	204.343	+ 0.2887	+ 0.2853	+ 0.2870	+3.4	—141.8	143.1766
29	26	50	1'208	205.551	+ 7.0615	+ 7.0678	+ 7.0640	—6.3	—148.1	150.2352
29	26	48	1'325	206.876	— 4.3386	— 4.3365	— 4.3376	—2.1	—150.2	145.8976
26	26	47	1'548	208.424	— 3.5671	— 3.5678	— 3.5674	+0.7	—149.5	142.3302
30	26	46	1'259	209.683	— 10.7991	— 10.7956	— 10.7974	—3.5	—153.0	131.5328
30	26	45	1'222	210.905	— 6.5313	— 6.5289	— 6.5301	—2.4	—155.4	125.0027
30, D. 2	25, 26	44	1'294	212.109	+ 3.9502	+ 3.9479	+ 3.9490	+2.3	—153.1	128.9517
D. 2	25	43	1'220	213.419	+ 5.0773	+ 5.0799	+ 5.0786	—2.6	—155.7	134.0303
25	Nov.	XXI	0.038	213.457	+ 0.3940	+ 0.3938	+ 0.3939	+0.2	—155.5	+ 134.4242
20	25	42	1'172	214.591	— 7.0808	— 7.0835	— 7.0822	+2.7	—153.0	126.9481
20	25	41	1'107	215.698	— 11.8862	— 11.8844	— 11.8853	—1.8	—154.8	115.0628
20	19	40	1'418	217.116	+ 3.5437	+ 3.5466	+ 3.5452	+2.9	—151.9	111.5176
21	19	39	1'313	218.429	— 6.1414	— 6.1359	— 6.1386	+5.5	—146.4	117.6562
21, 22, 23	19, 23	38	1'351	219.780	** + 11.9723	** + 11.9723	+ 11.9723	—0.0	—146.4	129.6285
21, 22, 23	19, 23	37	1'334	221.114	* + 11.9760	* + 11.9736	+ 11.9748	+2.4	—144.0	141.6033
22	19	36	1'355	222.469	— 1.4279	— 1.4307	— 1.4293	+2.8	—141.2	140.1740
22	19	35	1'349	223.818	+ 9.4356	+ 9.4336	+ 9.4346	+2.0	—139.2	149.6086
23	23	XX	0.261	224.079	+ 3.7447	+ 3.7454	+ 3.7450	—0.7	—139.9	+ 153.3536

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Results of geodetic spirit leveling in Mississippi, Tennessee, Kentucky, and Illinois, 1885-'90.

SECTION I.—FROM OKOLONA, MISS., TO GREENFIELD, TENN., OCTOBER, 1889, TO MARCH, 1890.

Date.	Benchmark.		Distance.		Difference of height between marks.			Discrepancy.		Height of mark above average Gulf level at Biloxi, Miss.
	From—	To—	Between successive marks.	From initial mark.	Direction of measure.		Mean.	Partial.	Total.	
					Forward (northward).	Backward (southward).				
1889-'90. Nov.										
16, 23	35	34	km. 1°308	km. 225°126	m. — 0°261	m. — 0°299	m. — 0°280	mm. +3·8	mm. —135·4	m. 148·6806
18	34	33	1°289	226°415	+ 10°223	+ 10°9183	+ 10°9203	+4·0	+131·4	159°6009
15	33	32	1°104	227°519	+ 4°5693	+ 4°5726	+ 4°5710	+3·3	+128·1	155°0299
18	32	31	1°155	228°574	— 5°2154	— 5°2142	— 5°2148	+1·2	+129·3	149°8151
11, 15	31	30	1°262	229°936	* 6°2438	* 6°2464	6°2451	+2·6	+126·7	143°5700
12, 15	31	30	1°262	229°936	* 6°2438	* 6°2464	6°2451	+2·6	+126·7	143°5700
12	30	29	1°170	231°106	— 2°1280	— 2°1293	— 2°1286	+1·3	+125·4	141°4414
12	29	28	1°054	232°160	— 4°2961	— 4°3001	— 4°2981	+4·0	+121·4	137°1433
12	28	27	1°050	233°210	— 0°3322	— 0°3331	— 0°3326	+0·9	+120·5	136°8107
13	27	26	1°132	234°342	+ 1°3711	+ 1°3702	+ 1°3706	+0·9	+119·6	138°1813
13	26	25	1°190	235°532	— 1°5239	— 1°5242	— 1°5240	+0·3	+119·3	136°6573
13, 14	25	24	1°082	236°014	* 1°1199	* 1°1178	+ 1°1189	+2·1	+117·2	137°7762
13	24	23	1°161	237°775	— 10°2227	— 10°2236	— 10°2232	+0·9	+116·3	127°5530
14	23	XIX	0°519	238°294	+ 3°0949	+ 3°0953	+ 3°0950	—0·7	—117·0	+ 130°6480
7	23	XVIII	0°161	237°936	+ 1°2976	+ 1°2963	+ 1°2970	+1·3	+115·0	+ 128°8500
8, 13	23	22	1°450	239°225	+ 0°7772	+ 0°7803	+ 0°7788	—3·1	—119·4	128°3318
8	22	21	1°063	240°288	— 6°6335	— 6°6326	— 6°6330	—0·9	—120·3	121°6688
6, 7	21	20	1°132	241°420	+ 1°0800	+ 1°0788	+ 1°0794	+1·2	+119·1	122°7782
8, 14	20	19	1°387	242°807	* 1°3666	* 1°3714	— 1°3690	+4·8	+114·3	121°4092
8, 9	19	18	1°111	243°918	— 10°3079	— 10°3103	— 10°3091	+2·4	+111·9	111°1001
9	18	17	0°961	244°879	— 1°0912	— 1°0887	— 1°0900	—2·5	—114·4	110°0101
9	17	16	1°291	246°170	— 3°6419	— 3°6381	— 3°6400	—3·8	—118·2	106°3701
1	16	15	1°315	247°485	+ 1°4194	+ 1°4249	+ 1°4222	—5·5	—123·7	107°7923

2, 6	1, 6	15	14	1'294	248.779	* + 5'9091	* + 5'9128	+ 5'9110	—3'7	—127.4	113.7033
2	I	I4	I3	I'286	250.065	+ 2'7948	+ 2'7996	+ 2'7972	—4.8	—132.2	116.5005
2	I, O. 29	I3	I2	I'440	251.505	— 5'9967	— 5'9933	— 5'9950	—3.4	—135.6	110.5055
O. 30	O. 29	I2	I1	I'295	252.800	+ 7'7842	+ 7'7798	+ 7'7820	+4.4	—131.2	118.2875
O. 30, N. 5	O. 29, N. 5	I1	I0	I'111	253.911	* + I'0864	* + I'0588	+ I'0626	+7.6	—123.6	129.3591
O. 30	O. 29	I0	9	I'088	254.999	— I'0850	— I'0838	— I'0684	—1.2	—124.8	118.6637
O. 30	O. 29	9	8	I'146	256.145	— 8.8715	— 8.8746	— 8.8730	+3.1	—121.7	109.7927
N. 5	N. 5	8	XVII	0.083	256.228	+ 1'7363	+ 1'7356	+ 1'7360	+0.7	—121.0	+111.5287
30, 31	29	8	7	I'184	257.329	— 5'7929	— 5'7898	— 5'7914	—3.1	—124.8	104.0013
31	28	7	6	I'265	258.594	— 2'5663	— 2'5656	— 2'5660	—0.7	—125.5	101.4353
31	28	6	5	I'185	259.779	— 4'0804	— 4'0798	— 4'0801	—0.6	—126.1	97.3552
31, N. 4	28, N. 4	5	4	0'998	260.777	* — 3'1184	* — 3'1226	— 3'1205	+4.2	—121.9	94.2347
N. 4, 5	28, N. 4	4	3	I'084	261.861	* + 6'7993	* + 6'7843	+ 6'7873	+6.0	—115.9	101.0220
26	25	3	2	I'050	262.911	+ I'03394	+ I'03386	+ I'03390	+0.8	—115.1	111.3610
28, 26	25, 28	2	I	I'278	264.189	* + I2.7024	* + I2.7045	+ I2.7634	—2.1	—117.2	124.1244
26	25	I	XV	I'163	265.352	+ 8.6540	+ 8.6513	+ 8.6526	+2.7	—114.5	+132.7770

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Supplementary heights (approximate) of points along the Mobile and Ohio and Illinois Central Railroad.

Location.	Description.	Height above aver- age Gulf level.
		<i>Metres.</i>
Shannon, Miss.,	County road crossing, 2 miles south of, ground	80.11
	Opposite Mobile and Ohio R. R. station, do.	73.95
	County road crossing, at Clarke's sawmill, middle of track; ground	74.73
Verona, Miss.,	Opposite Mobile and Ohio R. R. station, middle of track, ground	91.92
Tupelo, Miss.,	Crossing of Mobile and Ohio and Kansas City Belt R. R., ground	82.41
	In front of Mobile and Ohio R. R. freight depot, ground	83.66
Saltillo, Miss.,	County road crossing, $1\frac{1}{2}$ miles south of, middle of track, ground	90.06
	Opposite Mobile and Ohio R. R. station, do.	95.24
	County road crossing, 3 miles north of, middle of track, ground	106.34
Guntown, Miss.,	Opposite Mobile and Ohio R. R. station, middle of track, ground	116.10
Baldwyn, Miss.,	do., do.	114.04
Wheeler, Miss.,	County road crossing, middle of track, do.	109.25
Boonesville, Miss.,	County road crossing, 3 miles south of, middle of track, ground	118.14
	Ground on line with north end of Mobile and Ohio R. R. station, do.	153.60
Rienzi, Miss.,	County road crossing, $2\frac{1}{2}$ miles south of, ground	136.68
	Opposite north end of Mobile and Ohio R. R. station, do.	132.73
Corinth, Miss.,	County road crossing, $5\frac{1}{2}$ miles south of, do.	131.39
	County road crossing, 4 miles south of, do.	140.36
	Crossing Mobile and Ohio and Massillon and Cleveland R. R., ground	132.88
	County road crossing, 3 miles north of, do.	146.31
State line,	Crossing Mobile and Ohio R. R. and State line, ground	154.01
Corinth, Miss.,	County road crossing, 5 miles north of, do.	142.23
Ramer, Tenn.,	County road crossing, 1 mile south of, do.	126.42
	Opposite Mobile and Ohio R. R. station, do.	125.56
Falcon, Tenn.,	County road crossing, 3 miles south of, do.	125.59
	Opposite Mobile and Ohio R. R. station, do.	130.32
Selma, Tenn.,	County road crossing, do.	132.95
Bethel Springs, Tenn.,	Opposite Mobile and Ohio R. R. station, do.	139.76
	County road crossing, $1\frac{1}{2}$ miles north of, do.	144.30
	County road crossing, 4 miles north of, do.	155.68
McNairy, Tenn.,	Opposite Mobile and Ohio R. R. station, do.	136.85
	County road crossing, $3\frac{1}{2}$ miles north of, do.	129.65
Henderson, Tenn.,	Opposite Mobile and Ohio R. R. station, do.	128.49
Pinson, Tenn.,	County road crossing, 2 miles south of, do.	116.02
	County road crossing, 1 mile south of, do.	117.65
	Opposite Mobile and Ohio R. R. station, do.	115.96
Jackson, Tenn.,	Crossing Illinois Central and Mobile and Ohio R. R., ground	129.57
Oakfield, Tenn.,	County road crossing, Illinois Central R. R., $1\frac{1}{2}$ miles south of, ground	126.76
	Opposite mail stand, Illinois Central R. R., do.	134.31
	County road crossing, $\frac{1}{2}$ mile north of, do.	131.04
Medina, Tenn.,	County road crossing, 4 miles south of, do.	110.16
	County road crossing, $1\frac{1}{2}$ miles south of, do.	143.47
	Opposite Illinois Central R. R. station, do.	150.09

Supplementary heights (approximate) of points along the Mobile and Ohio and Illinois Central Railroad.

Location.	Description.	Height above aver- age Gulf level.
		<i>Metres.</i>
Medina, Tenn., Milan, Tenn.,	County road crossing, 2 miles north of, ground	162.09
	County road crossing, 5 miles south of, do.	149.03
	County road crossing, 3½ miles south of, do.	143.03
	County road crossing, 2½ miles south of, do.	137.90
	County road crossing, 1½ miles south of, do.	137.50
	Crossing of Illinois Central and Louisville and Nashville R. R., ground	128.44
Cadis Mill, Tenn., Idlewild, Tenn.,	County road crossing, 2 miles north of, do.	120.87
	County road crossing, 3 miles north of, do.	120.68
	County road crossing, do.	112.11
	County road crossing, 2 miles south of, do.	108.46
	County road crossing, 1 mile south of, do.	119.29
Bradford, Tenn.,	County road crossing, just north of, do.	111.98
	Opposite Illinois Central R. R. mail stand, do.	112.52
	County road crossing, 2 miles south of, do.	119.64
	County road crossing, 1 mile south of, do.	126.98
	In front of Illinois Central R. R. station, do.	110.17
	County road crossing, 2 miles north of, do.	99.93

Results of geodetic spirit leveling in Mississippi, Tennessee, Kentucky, and Illinois, 1885-90.

SECTION II.—FROM GREENFIELD, TENN., TO VILLA RIDGE, ILL., OCTOBER, 1888, TO JANUARY, 1889.

Date.	Benchmark		Distance		Difference of height between marks.			Discrepancy.		Height of mark above average Gulf level at Biloxi, Miss.
	From—	To—	Between successive marks.	From initial mark, K.	Direction of measure.		Mean.	Partial.	Total.	
					Forward (northward).	Backward (southward).				
1888-'89. Dec.	31 29 28 28 29 29 29 28 27 31 31 31 21 21 21 21 22 22 18	XV XV 102 101 100 99 98 97 96 95 94 XIV 93 92 91 90 89 88 87 86 85 84	km. ----- 0.094 0.070 1.225 1.199 1.259 1.526 1.054 1.061 1.064 0.096 1.399 1.292 0.982 0.608 0.726 1.210 1.285 1.252 1.244 1.218	km. 265.352 265.446 266.316 267.541 268.740 269.999 271.525 272.579 273.640 274.704 274.800 276.103 277.395 278.377 278.985 279.711 280.921 282.206 283.458 284.702 285.920	m. ----- 2.0392 0.1017 9.2622 12.2485 **--10.9921 0.0452 10.5991 10.7461 5.9380 1.3966 3.7581 11.8435 7.6315 5.2189 7.6193 1.9326 2.7597 0.9764 6.0779 2.7758	m. ----- 2.0396 0.1583 9.2588 12.2435 **--10.9889 0.0423 10.6004 10.7447 5.9373 1.3970 3.7537 11.8383 7.6290 5.2147 7.6180 1.9337 2.7573 0.9807 6.0752 2.7715	m. ----- 2.0394 0.1000 9.2605 12.2460 10.9905 0.0438 10.5998 10.7484 5.9376 1.3968 3.7559 11.8409 7.6302 5.2168 7.6186 1.9332 2.7585 0.9786 6.0766 2.7736	mm. ----- +0.4 -3.4 -3.4 -5.0 -3.2 -2.9 -1.3 +1.4 +0.7 -0.4 -4.4 -5.2 -2.5 +4.2 +1.3 -1.1 +2.4 -4.3 -2.7 +4.3	mm. ----- -114.5 -114.1 -117.5 -120.9 -125.9 -129.1 -132.0 -133.3 -131.9 -131.2 -131.6 -135.6 -140.8 -143.3 -139.1 -137.8 -138.9 -136.5 -140.8 -143.5 -139.2	

24	18	84	83	1.258	287.178	+ 7.0842	+ 7.0837	+ 7.0840	+0.5	-138.7	+124.3793
17	17	83	XIII	0.056	287.234	+ 2.2669	+ 2.2669	+ 2.2669	0.0	-138.7	+126.6462
17	18	83	82	0.729	287.907	- 3.5476	- 3.5462	- 3.5469	-1.4	-140.1	+120.8324
8	17	82	81	1.204	289.111	+ 2.0447	+ 2.0443	+ 2.0445	+0.4	-139.7	+121.0769
8	12	81	80	1.272	290.383	+ 2.0620	+ 2.0628	+ 2.0624	+0.8	-139.7	+123.1393
8, 17	12, 17	80	79	1.024	291.407	* -10.8002	* -10.8022	-10.8012	+2.0	-138.5	+112.3381
8	12	79	78	1.287	292.604	- 6.7615	- 6.7583	- 6.7599	-3.2	-141.7	+105.5782
8	12	78	77	1.114	293.808	- 6.1164	- 6.1108	- 6.1136	-5.6	-147.3	+ 99.4646
10	11, 12	77	76	1.315	295.123	+ 2.0876	+ 2.0879	+ 2.0878	-0.3	-147.0	+101.5524
10	11	76	XII	0.990	296.113	* - 6.6337	* - 6.6375	+ 6.6356	-3.8	-151.4	+108.1880
10, 14	11, 14	XII	75	0.990	297.103	* - 5.0139	* - 5.0100	+ 5.0115	-3.0	-154.4	+103.1765
10	11	75	74	1.291	298.394	+11.0746	+11.0760	+11.0753	-1.4	-155.8	+114.2518
10, 14	5, 11, 14	74	73	1.629	300.023	* + 5.7382	* + 5.7538	+ 5.7410	-5.6	-161.4	+119.9928
6	5	73	72	1.228	301.251	+ 2.6030	+ 2.6047	+ 2.6038	-1.7	-163.1	+122.5966
6	5	72	71	1.247	302.498	+ 3.1978	+ 3.1978	+ 3.1908	-2.1	-165.2	+125.7934
6	5	71	70	1.115	303.613	- 4.1472	- 4.1443	- 4.1458	-2.9	-168.1	+121.0476
6	5	70	69	1.093	304.706	-10.8645	-10.8647	-10.8646	+0.2	-167.9	+110.7830
6	5	69	68	1.007	305.773	- 2.5208	- 2.5184	- 2.5196	-2.4	-170.3	+108.2634
4	4	68	XI	0.088	305.861	+ 0.9090	+ 0.9096	+ 0.9093	-0.6	-170.9	+109.1727
6	4	68	67	0.937	306.710	+ 9.8413	+ 9.8381	+ 9.8397	+3.2	-167.1	+118.1031
7, 15	4, 15	67	66	1.026	307.736	* + 4.3100	* + 4.3147	+ 4.3124	-4.7	-171.8	+122.4155
7	4	66	65	0.900	308.636	- 6.4161	- 6.4154	+ 6.4158	+0.7	-171.1	+128.8313
7	3	65	64	1.046	309.682	- 0.1495	- 0.1382	- 0.1404	-4.3	-175.4	+128.6909
7	3	64	63	1.232	310.914	- 1.6734	- 1.6783	+ 1.6768	-2.9	-178.3	+130.3677
7	3	63	62	1.248	312.162	- 3.7772	- 3.7753	- 3.7762	-1.9	-180.2	+120.5915
7, 18	3, 18	62	61	1.248	313.410	* - 9.0300	* - 9.0256	- 9.0278	-4.4	-184.6	+117.5637
7, 13	3	61	60	1.230	314.640	- 5.0950	- 5.0918	- 5.0934	-3.2	-187.8	+111.5703
13	3, N, 28	60	X	1.146	315.786	- 0.6530	- 0.6551	+ 0.6540	-2.1	-189.9	+112.2243
13	3, N, 28	X	59	1.468	317.254	- 9.2722	- 9.2743	- 9.2732	+2.1	-187.8	+102.9511
30	Nov.	59	58	1.178	318.432	+ 1.6766	+ 1.6797	+ 1.6782	-3.1	-190.9	+104.6293
30	28	58	57	1.254	319.686	- 3.8157	- 3.8156	- 3.8156	-0.1	-191.0	+100.8137
30	27	57	56	1.221	320.907	- 3.9769	- 3.9732	- 3.9760	-1.7	-192.7	+ 96.8377
30	27	56	55	1.084	321.991	- 0.5039	- 0.4958	- 0.5018	-4.1	-196.8	+ 96.3359

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Results of geodetic spirit leveling in Mississippi, Tennessee, Kentucky, and Illinois, 1885-90.

SECTION II.—FROM GREENFIELD, TENN., TO VILLA RIDGE, ILL., OCTOBER, 1888, TO JANUARY, 1889.

Date.	Benchmark		Distance		Difference of height between marks.			Discrepancy.		Height of mark above average Gulf level at Biloxi, Miss.
	From—	To—	Between successive marks.	From initial mark, K.	Direction of measure.		Mean.	Partial.		
					Forward (northward).	Backward (southward).				
1888 '89. Nov.										
	27	54	km. 1'036	km. 323'027	m. + 1'6990	m. + 1'6971	m. + 1'6980	mm. +1'9	mm. -194.9	m. + 98'0339
	27	54	1'040	324'067	+ 8'5400	+ 8'5446	+ 8'5423	-4'6	-199'5	+ 106'5762
	27	53	1'180	325'247	+ 12'0295	+ 12'0340	+ 12'0318	-4'5	-204'0	+ 118'6080
	26	51	1'114	326'361	+ 4'4968	+ 4'5017	+ 4'4992	-4'9	-208'9	+ 123'1072
	15	50	1'125	327'486	* -11'3933	* -11'2999	-11'3016	-3'4	-212'3	+ 111'8056
	17	IX	0'339	327'825	+ 6'7436	+ 6'7462	+ 6'7449	- 2'6	-214'9	+ 118'5505
	19	50	1'266	328'752	- 6'6867	- 6'6839	- 6'6853	- 2'8	-215'1	+ 105'1203
	17	49	1'286	330'038	- 0'9042	- 0'8997	- 0'9020	- 4'5	-219'6	+ 104'2183
	17	47	1'228	331'266	- 2'4216	- 2'4185	- 2'4200	- 3'1	-222'7	+ 101'7983
	17	47	1'122	332'388	+ 11'2851	+ 11'2848	+ 11'2850	+ 0'3	-222'4	* + 113'0833
	16	46	1'150	333'538	+ 0'0061	+ 0'0018	+ 0'0040	+ 4'3	-218'1	* -113'0873
	16, 24	45	1'156	334'694	* -9'2772	* -9'2704	-9'2738	- 6'8	-224'9	* + 103'8135
16, 24	44	1'211	335'905	* -5'7004	* -5'6958	-5'6981	-4'6	-229'5	+ 98'1154	
16	43	1'168	337'073	- 0'6118	- 0'6097	- 0'6108	- 2'1	-231'6	+ 97'5046	
10, 16, 23, 24	42	41	0'942	338'015	* -0'0566	* -0'0522	- 0'0544	-4'4	-236'0	+ 97'4502
12, 21	41	40	1'352	339'367	* + 3'2287	* + 3'2334	+ 3'2310	-4'7	-240'7	+ 100'6812
10, 23	40	39	1'336	340'793	* + 1'4845	* + 1'4892	+ 1'4868	-4'7	-245'4	+ 102'1680
10, 23	39	VIII	341'733	341'733	* + 8'5105	* + 8'5148	+ 8'5126	-4'3	-249'7	+ 110'6806
9, 10, 23	VIII	38	1'176	342'909	* -3'0522	* -3'0462	-3'0492	- 6'0	-255'7	+ 107'6314
12, 22	38	37	1'270	344'179	* + 3'7275	* + 3'7263	+ 3'7269	+ 1'2	-254'5	+ 111'3583
9	37	36	1'280	345'459	* + 5'4424	* + 5'4444	+ 5'4434	- 2'0	-256'5	+ 116'8017
3, 22	37	.								

13	9	36	35	1'332	346.791	+13°6762	+13°6738	+13°6750	+ 24	-254.1	+130°4767
13	9	35	34	1'255	348.046	+ 2'2478	+ 2'2488	+ 2'2483	- 1.0	-255.1	+132°7250
13	3, 9	34	33	1'200	349.306	-12°7028	-12°7042	-12°7035	+ 1.4	-253.7	+120°0215
5	3	33	32	1'144	350.450	-10°2894	-10°2928	-10°2911	+ 3.4	-250.3	+109°7304
3	3	32	VII	0'342	350°792	+ 9°2417	+ 9°2417	+ 9°2417	0.0	-250.3	+118°9721
5	3	32	31	1'108	351°558	- 2'4061	- 2'4054	- 2'4058	- 0.7	-251.0	+107°3246
5	2, 3	31	30	1'134	352°692	- 2'8359	- 2'8314	- 2'8336	- 4.5	-255.5	+104°4910
5	2	30	29	1'243	353°935	+ 8'7552	+ 8'7590	+ 8'7571	- 3.8	-259.3	+113°2481
5	2	29	28	1'224	355°159	- 3'5202	- 3'5224	- 3'5213	- 2.2	-257.1	+109°7268
5	2	28	27	1'264	356°423	-10°3998	-10°3919	-10°3908	+ 2.1	-255.0	+99°3300
8, O 30	2	27	26	1'250	357°673	- 2'5325	- 2'5293	- 2'5309	- 3.2	-258.2	+96°8051
30	29	26	VI	0'984	358°657	- 0'1615	- 0'1590	- 0'1602	- 2.5	-260.7	+96°6449
30	29	25	25	1'466	360°123	- 0'2761	- 0'2714	- 0'2738	- 4.7	-265.4	+96°3711
30	29	25	24	1'040	361°163	+ 0'2333	+ 0'2365	+ 0'2349	- 3.2	-268.6	+96°0600
30	27	24	V	0'882	362°045	+ 1'2848	+ 1'2844	+ 1'2846	+ 0.4	-268.2	+97°8906
30, 31	27	V	23	1'304	363°349	+ 1'2002	+ 1'2045	+ 1'2024	- 4.3	-272.5	+99°0930
31	27	23	IV	0'998	364°347	+ 2'1063	+ 2'1113	+ 2'1088	- 5.0	-277.5	+101°2018
24	27	22	22	0'830	365°177	- 2'9262	- 2'9227	- 2'9244	- 3.5	-281.0	+98°2774
24, 31, N. 14	23	22	21	0'436	365°613	- 5'5295	- 5'5302	- 5'5298	+ 0.7	-280.3	+92°7476
24, 25	23	21	20	1'366	366°979	**+ 0'3019	+ 0'3015	+ 0'3017	- 2.9	-283.2	+98°2586
25	23	20	19	1'226	368°205	- 0'2401	- 0'2401	- 0'2410	+ 0.4	-282.8	+98°5603
25	23	19	18	1'191	369°306	- 6'6283	- 6'6181	- 6'6232	- 1.9	-284.7	+98°3193
25, N. 1, 14	20, N. 1	18	16	2'492	371°888	+ 6'5645	+ 6'5642	+ 6'5644	- 10.2	-294.9	+91°6961
25	25	16	III	0'296	372°184	+ 0'7628	+ 0'7602	+ 0'7615	+ 0.3	-294.6	+98°2605
10	10	16	15	0'856	372°744	**+ 6'4818	+ 6'4834	+ 6'4826	+ 2.6	-292.3	+92°4576
10, 12	16, 19	15	†U. S. E. 3	1'422	374°166	- 2'8148	- 2'8141	- 2'8144	- 1.6	-293.9	+98°9402
12, 15	16, 19	16	U. S. E. 1	0'531	374°697	+ 0'4077	+ 0'4074	+ 0'4076	- 0.7	-294.6	+96°1258
12	16	16	U. S. E. 1	0'325	375°022	- 2'5539	- 2'5505	- 2'5522	+ 0.3	-294.3	+96°5334
12	16	14	U. S. E. 2	1'030	376°052	+ 2'9716	+ 2'9714	+ 2'9715	- 3.4	-297.7	+93°9812
12	16	13	13	1'164	377°216	- 0'0003	- 0'0017	- 0'0010	+ 0.2	-296.1	+96°9527
12	16	13	12	1'151	378°367	+ 0'3086	+ 0'3113	+ 0'3100	+ 1.4	-296.1	+96°9517
12	16	12	II	0'890	379°257	+ 0'3086	+ 0'3113	+ 0'3100	- 2.7	-298.8	+97°2617

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† Crossing the Ohio River; observation made simultaneously.

Results of geodetic spirit leveling in Mississippi, Tennessee, Kentucky, and Illinois, 1885-'90.

SECTION II.—FROM GREENFIELD, TENN., TO VILLA RIDGE, ILL., OCTOBER, 1888, TO JANUARY, 1889.

Date.	Benchmark		Distance		Difference of height between marks.		Discrepancy.		Height of mark above average Gulf level at Biloxi, Miss.
	From—	To—	Between successive marks.	From initial mark, K.	Direction of measure.		Partial.	Total.	
					Forward (northward).	Backward (southward).			
1888-'89. Oct.									
13	11	10	km. 1.304	km. 380.561	m. + 0.0761	m. + 0.0802	mm. — 4.1	mm. — 302.9	m. + 97.3399
13	11	10	1.318	381.879	+ 0.1317	+ 0.1336	— 1.9	— 304.8	+ 97.4725
13, 18	9	8	0.941	382.820	*— 3.1300	*— 3.1260	— 4.0	— 308.8	+ 94.3445
13	8	7	1.196	384.016	+ 2.8838	+ 2.8815	+ 2.3	— 306.5	+ 97.2271
13	7	11	1.307	385.323	+ 1.6853	+ 1.6891	— 3.8	— 310.3	+ 98.9143
15	11	6	0.996	386.319	— 1.2644	— 1.2667	+ 2.3	— 308.0	+ 97.6487
8, 15	6	5	1.084	387.403	*— 0.0038	*— 0.0061	+ 2.3	— 305.7	+ 97.6437
9	5	1	0.298	387.701	— 0.2903	— 0.2914	+ 1.1	— 304.6	+ 97.3529
8	5	4	1.317	388.720	+ 3.7603	+ 3.7607	— 0.4	— 306.1	+ 101.4042
8	4	3	1.326	390.046	+ 5.6361	+ 5.6386	— 2.5	— 308.6	+ 107.0416
8, 17	3	2	1.251	391.297	*+ 8.1297	*+ 8.1302	— 0.5	— 309.1	+ 115.1716
9	2	1	1.210	392.597	+ 8.3399	+ 8.3407	— 0.8	— 309.9	+ 123.5119
9, 17	1	Z ₃	0.989	393.496	*— 6.7200	*— 6.7203	+ 0.3	— 309.6	+ 116.7917
5	Z ₃	Y ₃	0.124	-----	— 1.6770	— 1.6778	+ 0.8	-----	-----

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Results of geodetic spirit leveling in Mississippi, Tennessee, Kentucky, and Illinois, 1885-190.

SECTION III.—FROM VILLA RIDGE, ILL., TO ODIN, ILL., APRIL AND JUNE, 1885.

Date.	Bench mark		Distance		Difference of height between marks.			Discrepancy.		Height of mark above average Gulf level at Biloxi, Miss.
	From—	To—	Between successive marks.	From initial mark K.	Line run with		Mean.	Partial.		
					Rod E.	Rod F.				
1885. June.			<i>km.</i>	<i>km.</i>	<i>m.</i>	<i>m.</i>	<i>m.</i>	<i>mm.</i>	<i>mm.</i>	<i>m.</i>
4	Z ₃	Z ₃	0.130	393.496	— 1.6831	— 1.6830	— 1.6830	— 0.1	† 0.0	+ 116.7917
	Z ₃	Y ₃	0.127	393.623		— 1.6802	— 1.6802			— — — —
Mean. June.										+ 115.1115
4	Y ₃	146	1.322	394.945	— 6.9017	— 6.9014	— 6.9016	— 0.3	— 0.3	108.2099
3	146	145	1.238	396.183	— 4.0054	— 4.0026	— 4.0040	— 2.8	— 3.1	104.2059
4	145	XII _a	0.332	396.515	— 0.4499	— 0.4503	— 0.4501	+ 0.4	— 2.7	+ 103.7558
3	145	144	1.009	397.192	— 0.6936	— 0.6926	— 0.6931	— 1.0	— 4.1	+ 103.5128
3	144	143	0.956	398.148	+ 1.4270	+ 1.4258	+ 1.4264	+ 1.2	— 2.9	+ 104.9392
2	143	142	1.162	399.310	— 1.7729	— 1.7732	— 1.7730	+ 0.3	— 2.6	+ 103.1662
2	142	141	0.948	400.258	— 1.0033	— 1.0036	— 1.0034	+ 0.3	— 2.3	+ 102.1628
2	141	140	0.796	401.054	— 0.4167	— 0.4155	— 0.4161	— 1.2	— 3.5	+ 101.7467
1	140	139	0.182	401.236	— 0.2007	— 0.2010	— 0.2008	+ 0.3	— 3.2	+ 101.5459
1	139	138	0.960	402.196	+ 1.2218	+ 1.2237	+ 1.2228	— 1.9	— 5.1	+ 102.7687
1	138	137	0.970	403.166	+ 0.2911	— 0.2890	— 0.2900	— 2.1	— 7.2	+ 102.4787
1	137	136	1.001	404.167	— 0.4939	— 0.4917	— 0.4928	— 2.2	— 9.4	+ 101.9859
May.										
	136	135	0.842	405.009	+ 0.5375	+ 0.5377	+ 0.5376	— 0.2	— 9.6	+ 102.5235
	135	134	1.012	406.021	— 1.5279	— 1.5315	— 1.5297	+ 3.6	— 6.0	+ 100.9938
	134	X ₃	0.910	406.931	+ 1.0339	+ 1.0327	+ 1.0333	+ 1.2	— 4.8	+ 102.0271
	X ₃	133	0.560	407.491	+ 0.5119	+ 0.5121	+ 0.5120	— 0.2	— 5.0	+ 102.5391

† A new start occasioned by the change in method of observing.

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Date.	Bench mark		Distance		Difference of height between marks.		Discrepancy,		Height of mark above average Gulf level at Biloxi, Miss.
	From—	To—	Between successive marks,	From initial mark K.	Line run with	Mean.	Partial.	Total.	
			km.	km.	Rod E.	Rod F.	E. F.	Accumulated.	m.
1885.					m.	m.	mm.	mm.	m.
May.									
29	133	132	0.791	408.282	— 0.4613	— 0.4574	—3.9	—8.9	+102.0797
28	132	131	1.323	409.605	+ 0.9060	+ 0.9042	+1.8	—7.1	+102.0848
28	131	130	1.068	410.673	+ 0.6246	+ 0.6256	—1.0	—8.1	+103.6099
28	130	129	1.102	411.775	+ 2.0537	+ 2.0526	+1.1	—7.0	+105.6631
28	129	128	1.087	412.862	+ 1.5932	+ 1.5950	—1.8	—8.8	+107.2572
27	128	127	1.102	413.964	+ 1.0328	+ 1.0333	—0.5	—9.3	+108.2902
27	127	126	1.116	415.080	+ 2.6794	+ 2.6827	—3.3	—12.6	+110.9712
27	126	125	1.099	416.179	+ 3.0293	+ 3.0312	—1.9	—14.5	+114.0014
27	125	124	1.127	417.306	+ 2.4325	+ 2.4293	+3.2	—11.3	+116.4323
26	124	123	1.281	418.587	+ 3.7083	+ 3.7073	+1.0	—10.3	+120.1401
25	123	122	0.975	419.562	+ 7.4480	+ 7.4461	+1.9	—8.4	+127.5871
25	122	121	0.968	420.530	+ 6.9255	+ 6.9268	—1.3	—9.7	+134.5133
25	121	120	1.831	422.361	+ 14.3573	+ 14.3631	—5.8	—15.5	+148.8735
23	120	119	0.874	423.235	— 4.2688	— 4.2671	—1.7	—17.2	+144.6055
23	119	118	1.011	424.246	— 4.3739	— 4.3765	+2.6	—14.6	+140.2303
23	118	117	1.552	425.798	+ 10.5299	+ 10.5279	+2.0	—12.6	+150.7592
22	117	116	1.028	426.826	+ 6.9973	+ 6.9952	+2.1	—10.5	+157.7554
22	116	115	1.006	427.832	+ 7.3985	+ 7.3958	+2.7	—7.8	+165.1526
22	115	114	0.978	428.810	+ 5.4829	+ 5.4859	—3.0	—10.8	+170.6370
22	114	113	0.966	429.776	+ 4.8503	+ 4.8517	—1.4	—12.2	+175.4880
22	113	112	1.029	430.805	+ 6.7166	+ 6.7124	+4.2	—8.0	+182.2025
21	112	111	0.854	431.659	+ 5.9285	+ 5.9290	—0.5	—8.5	+188.1313

21	III	II0	I'016	432·675	+ 2·4296	+ 2·4312	+ 2·4304	—1·6	—10·1	+190·5617
26	II0	W ₃	0·175	432·850	+ 0·3688	+ 0·3689	+ 0·3688	—0·1	—10·2	+190·9305
21	II0	109	0·956	433·631	— 2·0681	— 2·0709	— 2·0695	+2·8	— 7·3	+188·4922
21	109	108	0·962	434·593	— 2·7438	— 2·7422	— 2·7430	+1·6	— 5·7	+191·2352
21	108	XI _A	1·068	435·661	— 0·1298	— 0·1305	— 0·1302	+0·7	— 5·0	+191·1050
13	XI _A	85	0·996	436·657	— 1·4454	— 1·4479	— 1·4466	+2·5	— 4·3	+189·6584
13	85	86	0·976	437·633	— 1·9838	— 1·9856	— 1·9847	+1·8	— 4·3	+191·6431
13	86	87	0·972	438·605	— 1·3718	— 1·3723	— 1·3720	+0·5	— 3·8	+190·2711
13	87	88	1·523	440·128	— 8·4779	— 8·4730	— 8·4754	+4·9	— 8·7	+181·7957
14	88	89	0·978	441·106	— 4·9997	— 4·9985	— 4·9991	—1·2	— 9·9	+176·7966
14	89	90	0·763	441·869	+ 5·1913	+ 5·1918	+ 5·1916	—0·5	—10·4	+181·9882
14	90	91	0·963	442·832	— 5·8892	— 5·8880	— 5·8886	—1·2	—11·6	+176·0996
14	91	92	0·976	443·808	— 7·2045	— 7·2041	— 7·2043	—0·4	—12·0	+168·8953
14	92	93	1·038	444·846	— 6·9093	— 6·9056	— 6·9074	—3·7	—15·7	+161·9879
15	93	94	0·992	445·838	* — 6·8766	* — 6·8767	— 6·8767	+0·2	—15·5	+155·1112
15	94	95	1·426	447·264	— 9·7114	— 9·7130	— 9·7122	+1·6	—13·9	+145·3990
16	95	96	1·055	448·319	— 4·2316	— 4·2317	— 4·2316	+0·1	—13·8	+141·1074
16	96	97	0·978	449·297	— 1·8170	— 1·8196	— 1·8183	+2·6	—11·2	+139·3491
16	97	98	0·952	450·249	— 4·4107	— 4·4101	— 4·4104	—0·6	—11·8	+134·9387
16	98	99	0·940	451·189	— 2·2511	— 2·2535	— 2·2523	+2·4	— 9·4	+132·6864
16	99	100	1·010	452·199	+ 0·4421	+ 0·4396	+ 0·4408	+2·5	— 6·9	+133·1272
18	100	101	1·356	453·555	— 2·0944	— 2·0900	— 2·0922	—4·4	—11·3	+131·0350
18	101	102	0·982	454·537	— 1·4565	— 1·4620	— 1·4592	+5·5	— 5·8	+129·5758
18, 20	102	V ₃	0·402	454·939	** + 0·9480	** + 0·9476	+ 0·9478	+0·4	— 5·4	+130·5236
18, 20	103	103	0·872	455·811	** — 28131	** — 28134	— 28132	+0·3	— 5·1	+127·7104
19	V ₃	104	1·029	456·840	— 0·9453	— 0·9437	— 0·9445	—1·6	— 6·7	+127·0659
19	104	105	1·044	457·884	— 1·4617	— 1·4623	— 1·4620	+0·6	— 8·1	+125·6039
19	105	106	0·655	458·539	+ 0·3565	+ 0·3586	+ 0·3576	—2·1	— 8·2	+125·9615
20	106	107	0·944	459·483	— 2·6150	— 2·6136	— 2·6143	—1·4	— 9·6	+123·3472
20	107	84	1·002	460·485	+ 2·1777	+ 2·1750	+ 2·1764	+2·7	— 6·9	+125·5236
12	84	83	1·114	461·599	+ 6·1537	+ 6·1523	+ 6·1530	+1·4	— 5·5	+131·0766
12	83	82	1·145	462·744	+ 2·6632	+ 2·6666	+ 2·6649	—3·4	— 8·9	+134·3415
12	82	X _A	1·112	463·856	— 4·3952	— 4·3903	— 4·3928	—4·9	—13·8	+129·0487
6	X _A	63	1·112	464·968	* — 0·8666	* — 0·8602	— 0·8604	—0·4	—14·2	+129·8883
4, 6	63	64	0·652	465·620	* — 4·1992	* — 4·2000	— 4·1996	+0·8	—13·4	+124·8887
6	64	T ₃	0·672	466·292	+ 0·8121	+ 0·8146	+ 0·8134	—2·5	—15·9	+125·7021

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	From—	To—	Between successive marks.	From initial mark K.	Line run with		Mean.	Partial	Total.		
					Rod E.	Rod F.					
1885. May.											
	T ₃	65	km. 1'136	km. 467'428	m. —	m. —	m. —	mm. +0'2	mm. —15'7	m. +119'3830	
	65	70	1'118	468'546	—	3'0085	3'0084	+0'1	—15'6	+116'3746	
	70	71	1'127	469'673	—	2'5467	2'5474	+1'4	—17'0	+118'9220	
	71	72	0'962	470'635	—	1'6667	1'6664	—0'7	—17'7	+117'2556	
	72	73	1'063	471'698	+	3'1584	3'1592	+2'4	—15'3	+120'4148	
	73	U ₃	1'134	472'832	+	3'8644	3'8655	+2'2	—13'1	+116'5493	
	U ₃	81	1'324	474'156	—	0'7111	0'7100	—2'2	—15'3	+115'8393	
	81	80	0'934	475'090	+	2'3475	2'3494	—3'7	—19'0	+118'1887	
	80	79	1'633	476'723	+	0'8702	0'8690	+2'3	—16'7	+119'0577	
	79	78	1'136	477'859	—	0'8876	0'8862	—2'7	—19'4	+118'1715	
	78	77	0'940	478'799	+	3'6725	3'6720	+0'9	—18'5	+121'8435	
	77	76	1'138	479'937	+	0'4596	0'4608	—2'3	—20'8	+122'3643	
	76	75	1'010	480'947	—	1'5828	1'5832	+0'8	—20'0	+120'7211	
	75	74	1'456	482'403	—	1'1611	1'1600	—2'1	—22'1	+119'5611	
	74	69	1'179	483'582	+	1'7745	1'7757	—2'4	—24'5	+121'3368	
	69	68	1'406	484'988	+	0'8582	0'8576	+1'3	—23'2	+122'1944	
	68	67	1'116	486'404	—	1'6000	1'5988	—2'5	—25'7	+120'5956	
	67	66	1'136	487'240	+	0'7681	0'7694	—2'7	—28'4	+121'3650	
	66	62	1'166	488'406	+	0'9857	0'9844	+2'5	—25'9	+122'3494	
	62	61	0'937	489'343	—	1'9184	1'9138	—4'6	—30'5	+120'4333	
	61	60	1'137	490'480	+	0'9144	0'9133	+1'1	—29'4	+121'3471	
	60	59	1'081	491'561	+	1'8457	1'8468	—2'2	—31'6	+123'1939	
	59	58	1'149	492'710	+	4'5999	4'5976	+4'7	—26'9	+127'7915	

	58	57	493.879	—1.2550	—1.2544	—1.2547	—0.6	—27.5	+156.5368
22	31	1.909	501.157	—0.7163	—0.7172	—0.7168	+0.9	—24.0	+138.5112
23	32	1.239	502.306	—3.2802	—3.2790	—3.2796	+1.2	—25.2	+135.2316
23	33	1.390	503.786	+1.3167	+1.3132	+1.3150	+3.5	—21.7	+130.5466
24	34	1.171	504.957	+3.7370	+3.7355	+3.7362	+1.5	—20.2	+140.2828
25	35	1.171	506.128	+2.6436	+2.6455	+2.6446	+1.9	—22.1	+142.9274
26	36	1.244	507.372	+2.8710	+2.8695	+2.8702	+1.5	—20.6	+145.7976
27	37	1.220	508.592	+3.5859	+3.5852	+3.5856	+0.7	—19.9	+149.3832
28	38	1.140	509.732	+2.8122	+2.8147	+2.8134	—2.5	—19.4	+152.1966
29	39	1.060	510.792	—0.8240	—0.8239	—0.8240	—0.1	—22.5	+151.3726
30	40	1.475	512.267	+1.1311	+1.1308	+1.1310	+0.3	—22.2	+152.5036
31	41	1.220	513.487	+1.7863	+1.7865	+1.7864	+0.2	—22.0	+150.7172
32	42	1.248	514.735	+2.8939	+2.8920	+2.8930	+1.9	—20.1	+153.6102
33	43	1.883	516.618	+1.4003	+1.3987	+1.3995	+1.6	—18.5	+155.0097
34	44	1.173	517.701	—0.3384	—0.3329	—0.3356	—5.5	—24.0	+154.6741
35	45	1.176	518.967	+1.3358	+1.3357	+1.3358	+0.1	—23.9	+156.0099
36	46	1.149	520.116	+1.0702	+1.0668	+1.0685	+3.4	—20.5	+157.0784
37	47	0.914	521.039	**+2.2390	**+2.2278	+2.2289	+2.2	—18.3	+159.3073
38	48	1.209	522.239	—1.5375	—1.5370	—1.5372	—0.5	—18.8	+157.7701
39	49	1.163	523.402	—5.6879	—5.6892	—5.6886	+1.3	—17.5	+152.0815
40	50	1.198	524.600	+1.1825	+1.1821	+1.1833	+4.4	—13.1	+153.9048
41	51	0.618	525.218	—2.6702	—2.6793	—2.6792	+0.1	—13.0	+151.2256
42	52	1.154	526.372	+3.3959	+3.3967	+3.3978	+2.2	—10.8	+154.6234
43	53	1.660	528.032	+2.5075	+2.5075	+2.5075	0.0	—10.8	+157.1309
44	54	1.130	529.171	—0.1079	—0.1085	—0.1082	+0.6	—10.2	+156.9327
45	55	1.028	530.799	+5.5797	+5.5745	+5.5726	—3.8	—14.0	+162.5053
46	56	1.180	531.979	—0.9260	—0.9256	—0.9256	—0.4	—14.4	+161.5795
47	57	1.181	533.160	+3.5621	+3.5617	+3.5619	+0.4	—14.0	+165.1414
48	58	1.387	534.547	+3.1002	+3.1003	+3.1002	—0.1	—14.1	+168.2416
49	59	0.410	534.957	+0.9339	+0.9320	+0.9330	+1.9	—12.2	+169.1746

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	From—	To—	Between successive marks.	From initial mark K.	Line run with		Mean.	Partial.	Total.	
					Rod E.	Rod F.				
1885. Apr.										
			<i>km.</i>	<i>km.</i>	<i>m.</i>	<i>m.</i>	<i>m.</i>	<i>mm.</i>	<i>mm.</i>	<i>m.</i>
	20	27	1.189	535.736	-2.3288	-2.3258	-2.3273	-3.0	-17.1	+165.9143
	20	26	1.182	536.918	+1.0936	+1.0950	+1.0943	-1.4	-18.5	+167.0086
	20	25	1.203	538.121	-4.0192	-4.0187	-4.0190	-0.5	-19.0	+162.9896
	18	24	1.888	540.009	-0.8823	-0.8827	-0.8825	+0.4	-18.6	+162.1071
	18	23	1.172	541.181	+2.6108	+2.6145	+2.6126	-3.7	-22.3	+164.7197
	18	P ₃	1.136	542.317	+5.7136	+5.7174	+5.7155	-3.8	-26.1	+170.4352
	18	P ₃	1.214	543.531	-2.6605	-2.6643	-2.6624	+3.8	-22.3	+167.7728
	18	22	1.662	545.193	-4.0904	-4.0920	-4.0912	+1.6	-20.7	+163.6816
	17	21	1.143	546.336	-3.1655	-3.1671	-3.1663	+1.6	-19.1	+160.5153
	17	20	1.155	547.491	-2.2395	-2.2392	-2.2394	-0.3	-19.4	+158.2759
	17	19	0.922	548.413	-2.0408	-2.0384	-2.0396	-2.4	-21.8	+156.2363
	17	18	1.149	549.562	-3.7282	-3.7293	-3.7288	+1.1	-20.7	+152.5075
	15	16	0.665	550.227	-1.2598	-1.2570	-1.2584	-2.8	-23.5	+151.2491
	15	15	1.346	551.573	-3.2658	-3.2618	-3.2638	-4.0	-27.5	+147.9853
	15	14	1.573	553.146	+1.2283	+1.2294	+1.2288	-1.1	-28.6	+149.2141
	15	13	0.921	554.067	+0.4924	+0.4929	+0.4926	-0.5	-29.1	+149.7067
	14	12	1.109	555.176	+0.0118	+0.0162	+0.0140	-4.4	-33.5	+149.7207
	14	11	1.160	556.336	-0.1511	-0.1503	-0.1507	-0.8	-34.3	+149.5700
13, 16, 17	N ₃	7	0.989	557.325	** +0.8354	** +0.8401	+0.8377	-4.7	-39.0	+150.4077
13	8	1.071	558.396	-2.1482	-2.1465	-2.1474	-1.7	-40.7	+148.2603	
13, 14	O ₃	9	1.438	559.834	* -5.8040	* -5.8035	-5.8038	-0.5	-41.2	+142.4565
13	O ₃	9	0.856	560.690	+2.5133	+2.5157	+2.5145	-2.4	-43.6	+144.9710
14	10	1.142	561.832	+2.4235	+2.4242	+2.4238	-0.7	-44.3	+147.3948	
14	10	0.676	562.508	+0.8138	+0.8124	+0.8131	+1.4	-42.9	+148.2079	

The probable errors of the resulting heights will have to depend on the discordances of the forward and backward measures for Sections I and II, and on the differences between results by rods E and F for the simultaneous lines of Section III. Results thus obtained do not take into account systematic or constant errors to which the observations are known to be liable; this latter class of uncertainty can only be recognized by the closing of loops of lines of levels. The phenomenon of accumulation of errors in the same direction is quite prominent in Section II, where, in a distance of 128^{km.}, and during about three months (October to January), the discrepancy rises from 114^{mm.} to 310^{mm.} in a surprisingly steady manner; the rate of divergence is 1.53^{mm.} per kilometre (or in angular value 0.3''), and is apparently uninfluenced by the varying circumstances during the measure of the line.* The serious part of this behavior is the fact that we have no assurance that the mean result of the two measures converges to or diverges from the true value of the level. Throughout the line the temporary marks are about equally distributed and not far from a kilometre apart; hence we use the formula for the probable error per km. for double leveling $r_{II} = 0.675 \sqrt{\frac{[dd]}{4[s]}}$ and for the terminal point at the distance $S=[s]$ the value $r = 0.675 \sqrt{\frac{[dd]}{4}}$

Table of probable errors of results.

Designation of line of levels.	$S=[s]$	$[dd]$	$n.$	r_{II}	r
	<i>km.</i>			<i>mm.</i>	<i>mm.</i>
Biloxi, Miss. (Tidal mark), to Mobile, Ala. (A).	94.3	454	94	± 0.74	± 7.2
Mobile, Ala. (A), to Meridian, Miss. (C).	219.2	1084*	178	± 0.83	± 11.8
Meridian, Miss. (C), to Okolona, Miss. (K).	204.2	875*	138	± 0.87	± 12.5
Okolona, Miss. (K), to Corinth, Miss. (V).	109.5	839	100	± 0.93	± 9.8
Corinth, Miss. (V), to Greenfield, Tenn. (XV).	155.9	2157	135	± 1.25	± 15.7
Greenfield, Tenn. (XV), to Villa Ridge, Ill. (Z ₃).	128.2	1175	112	± 1.02	± 11.6
Villa Ridge, Ill. (Z ₃), to Odin, Ill. (V)	176.0	809*	160	± 0.91	± 12.1

* Part of this distance consists of simultaneous parallel lines, i. e., the part from Mobile to Citronelle, Ala., for which $[dd] = 225$ and $[s] = 53.66$, here we substitute $1.6 [dd]$ for $[dd]$, and we likewise multiply by 1.6 the $[dd]$ of the other two marked (*) lines in order to allow (empirically) for the fact that such lines do not develop the whole of the discrepancies. This amounts to increasing the probable error by 25 per cent in order to give a more correct value and one more comparable with independent lines. (See App. No. 10, Report for 1888, p. 423.)

Since the mean error m_1 of a single leveling of a kilometre is frequently used for purposes of comparison, it is given below, computed

* In the parallel simultaneous lines of Section III the discrepancy rises slowly but more rapidly towards the end and always with the same sign from 0 to 41^{mm.} in 176^{km.}, evidently part of the difference being common to the two lines; hence it disappears in the comparison.

by $m_1 = \sqrt{\frac{[dd]}{2[s]}}$. For lines from Okolona to Greenfield $m = \pm 2.38^{\text{mm}}$,

Greenfield to Villa Ridge $m_1 = \pm 2.14^{\text{mm}}$, and from Villa Ridge to Odin $m_1 = \pm 1.90^{\text{mm}}$, the last increased by one-fourth of its amount.

The total resulting *probable* error of leveling between Biloxi and Odin, a distance of 1 087^{km}, sums up as follows:

$\sqrt{[r^2]} = \pm 31.1^{\text{mm}}$ for uncertainty in leveling, and $\pm 25.0^{\text{mm}}$ for uncertainty in the tidal level, hence by combination the height and probable error of the Odin bench mark V becomes . . . 159.617^m $\pm 0.040^{\text{m}}$.

Closing of loops.—In the first place we have the grand loop:

Sandy Hook, N. J., Odin, Ill., and Biloxi, Miss., with Gulf and ocean.

Appendix No. 11, Report for 1882, p. 552, gives for height of bench mark V at Odin 161.348^m $\pm 0.047^{\text{m}}$, hence the discrepancy 1.731^m. The part of the line from Hagerstown, Md., to Odin has no checks, nor is the identity of the Gulf and Atlantic levels assured; the assigned probable errors evidently do not represent the true state of the case.

Second loop: Cairo, Odin, St. Louis, Cairo.

	<i>m.</i>	<i>Distance.</i> <i>km.</i>
I. $\left\{ \begin{array}{l} \Delta h \text{ Cairo (I) to Odin (V),} \\ \Delta h \text{ Odin (V) to St. Louis (J}_3 \text{ or K}_3\text{),} \\ \Delta h \text{ St. Louis (J}_3 \text{ or K}_3\text{) to Cairo (I),} \end{array} \right.$	$\begin{array}{r} +63.4908 \\ -34.4398 \\ -29.2737 \end{array}$	$\begin{array}{r} 194.7 \\ 103.6 \\ 275.7 \end{array}$
Closing error,	-0.2227	Report Miss. River Comm'n, 1883.

Third loop: Corinth, Cairo, Memphis, Corinth.

	<i>m.</i>	<i>km.</i>
II. $\left\{ \begin{array}{l} \Delta h \text{ Corinth (V) to Cairo (I),} \\ \Delta h \text{ Cairo (I) to Memphis (U. S. B. M.),} \\ \Delta h \text{ Memphis (U. S. B. M.) to Cor-} \\ \text{inth (V),} \end{array} \right.$	$\begin{array}{r} -41.1023 \\ -16.3222 \\ +57.2160 (?) \end{array}$	$\begin{array}{r} 265.2 \\ 330.8 \\ 153.1 (?) \end{array}$
Closing error,	-0.2085	Report Miss. River Comm'n, 1881-'83. Field comp'n.*

Fourth loop: Biloxi, Mobile, Corinth, Memphis, Vicksburg, New Orleans, Biloxi.

	<i>m.</i>	<i>km.</i>
III. $\left\{ \begin{array}{l} \Delta h \text{ Biloxi (T. B. M.) to Corinth (V),} \\ \Delta h \text{ Corinth (V) to Memphis} \\ \text{(U. S. B. M.),} \\ \Delta h \text{ Memphis (U. S. B. M.) to Biloxi} \\ \text{(T. B. M.),} \end{array} \right.$	$\begin{array}{r} +137.2281 \\ -57.2160 (?) \\ -80.3192 \end{array}$	$\begin{array}{r} 627.3 \\ 153.1 (?) \\ 1053.8 \end{array}$
Closing error,	-0.3071	Reports Miss. River Comm'n.

Making use of the conventional expression $5 \sqrt{[s]}$ to indicate the greatest closing error that might be tolerated in a line, we have for the

*The office computation was nearly completed by Mr. Nelson when he was assigned to other duty.

above loops I, II, III, 0.120^m , 0.137^m , and 0.214^m ; since the actual errors* are in excess of these numbers the above degree of standard accuracy is not attained, still the results may be accepted provided, as is highly desirable, that the tie line Vicksburg to Meridian (proposed in 1887) be sup-



plied, forming one more loop and sustaining the Mississippi River Commission loop Vicksburg, Shreveport, Fort Adams. Indeed, from a letter of Capt. J. H. Willard to the Chief of Engineers (November 8, 1890), it appears that Vicksburg and Meridian have been connected by ordi-

* They correspond to about $7 \sqrt{[s]}$

nary railroad leveling, and are said to show a discrepancy of about 1 foot as compared with our result.

In consequence of the earth's rotation, the equipotential surfaces that may be passed through Biloxi and Odin will converge toward the north; the convergence will amount to $\Delta = -0.00514^m h \Delta \varphi \sin 2\varphi$, where $\Delta \varphi$ = difference in latitude (expressed in parts of the radius). For latitudes $30^\circ 24'$ and $38^\circ 38'$ and $h = 126^m$ we have $\Delta = -0.087^m$, a quantity of the same order of magnitude as the observing error. For *uniform* slope of profile one-half of this amount, or 0.044^m , would have to be subtracted from the elevation of the northern station. The expression for Δ depends on the relation $h_1 g_1 = h_2 g_2$, a constant, which must hold between any two adjacent equipotential surfaces, g representing gravity and h the corresponding distance between them, and this forms the basis of the so-called orthometric correction, now recognized as a necessity in refined leveling. This will be attended to; together with the adjustment of the loops, as soon as the needed data are all on hand.

I close this report with a statement of the several independent and unadjusted results for height of St. Louis, Mo. (B. M's. J₃ and K₃ at Bridge.)

1. By the Mississippi River route, Biloxi, New Orleans, Vicksburg, etc.	125.915 ^{m.}
2. By the Meridianal route, Biloxi, Mobile, Corinth, Odin, etc.	125.177
(The difference of 1 and 2 equals the sum of the closing errors of the 3 loops.)	
3.* By the Great Lakes, Sandy Hook, Albany, Chicago, etc.	126.100 ^L
4. By the 39th parallel route, Sandy Hook, Cincinnati, etc.	126.908

For the present we may adopt the preliminary value 125.8 m. or 412.7 feet.

* Water levels, in part.

SECTION I.—*Location and description of permanent bench marks between Okolona, Miss., and Greenfield, Tenn.*

- K.—At Okolona, Chickasaw County, Miss. Center of bolt leaded horizontally into a brick on the east front, and near the south end of cotton warehouse occupied by C. R. Smith. The brick is the thirteenth one south of the door and in the twenty-second course from the ground.
- L.—At Okolona, Miss. The center of a copper bolt leaded into a brick on the southwest pier of the Mobile and Ohio Railroad station. The brick is the middle one on the west side of the pier, and is on the seventh course from the ground.
- M.—On the Mobile and Ohio Railroad bridge over Tubby Lubby Creek. The bottom of a square cavity cut in the capstone of the pier on the north bank of the creek. It is west of the track and is roughly lettered:

U. S.
□
B. M.

- N.—At Shannon, Lee County, Miss. The center of a cross cut on a brass bolt leaded horizontally into a brick in the east wall of R. B. Clark & Co.'s store. The brick is in the sixth row above the foundation, and is the sixth one from the north end of wall.
- O.—At Verona, Lee County, Miss. The center of a cross cut on a brass bolt leaded horizontally into a brick in the south front of R. L. Trice & Son's store. The brick is in the sixth row above the foundation and is the third one from the west side.
- P.—At Tupulo, Lee County, Miss. The center of a cross cut on a brass bolt leaded horizontally into a brick in the front wall of Fulton Hotel. The brick is in the twenty-first course above the ground, and is the second one from the southeast corner.
- Q.—At Sattillo, Lee County, Miss. The bottom of a square cavity cut in a limestone block set in the front yard of James R. Boling's house, near the northwest corner of the brick flower pit on the south side of the house. The block is 6 inches square, projects 6 inches above the ground, and is marked thus:

U. S.
□
B. M.

- R.—At Guntown, Lee County, Miss. The center of a cross cut on a brass bolt leaded horizontally into a brick in the chimney on the north end of J. W. Kernodle's house. The brick is in the twelfth

course above the ground, and is the second one from the outer face of chimney on the side toward the front of the house.

S.—At Baldwyn, Lee County, Miss. The bottom of a square cavity cut in a limestone block set in the southwest corner of the yard to the Bucey Hotel. The block is 6 inches square, projects 6 inches from the ground, and is marked thus:

U. S.

□

B. M.

T.—At Booneville, Prentiss County, Miss. The center of a cross cut on a brass bolt leaded horizontally into a brick in the east front of the court-house. The brick is in the eighteenth course below the window sill, and is the second one from the northeast corner

U.—At Rienzi, Alcorn County, Miss. The center of a cross cut on a copper bolt leaded horizontally into a brick in the outer face of the north chimney on the east side of Taylor's Hotel. The brick is in the fifteenth course above the ground, and is the third one from the north side of chimney.

V.—At Corinth, Alcorn County, Miss. The center of a cross cut in a brass bolt leaded horizontally into a brick in the east wall of a store on Waldren street. The building is opposite the court-house, and is used as the city hall. The brick is in the third course above the sill of the window, near the north end of building, and is the fourth one south of this window.

W.—At Corinth, Miss. The center of a cross cut in a brass bolt leaded horizontally into a brick in the west wall of court-house. The brick is in the fourteenth row below the line of window sills, and in the fifth one south of the fifth cellar ventilator, counting from the northwest corner of the building.

X.—At Ramer, McNairy County, Tenn. The center of a cross cut in a brass bolt leaded horizontally into a brick in the pier under the southwest corner of the Mobile and Ohio Railroad station. The brick is in the fourth course from the top of pier, and is the one on the southeast corner. The end of the bolt is about one-fourth inch below the outer face of the brick.

Y.—At Falcon, McNairy County, Tenn. A brass bolt leaded horizontally into a brick in the chimney on the south end of a house, owned by the Mobile and Ohio Railroad Company, standing a short distance north of the railroad station, on the west side of track. The brick is the second one from the southeast corner of the chimney, in the sixth course above the foundation, on the side fronting the railroad track.

Z.—At Bethel Springs, McNairy County, Tenn. The surface inclosed between two file marks, about 1 inch apart, on one of the raised portions of the corrugated iron door sill of Stovall, Epps & Hendrix

Co.'s brick storehouse. The mark is $5\frac{1}{2}$ inches from the front edge of the sill and $5\frac{1}{2}$ inches from the wall forming the south side of the building.

XXVII.—At McNairy, McNairy County, Tenn. The bottom of a square cavity cut in the rock foundation of the chimney at the south end of E. W. Sheffield's house, near the southeast corner of the chimney. The house is on the west of and fronts the railroad, about one-fourth mile south of the station.

XXVI.—At Henderson, Chester County, Tenn. The center of a cross cut on a brass bolt leaded horizontally into a brick in the south wall of J. F. Hamlett's storehouse. The house is west and a short distance north of the railroad station, facing the railroad track. The brick is in the fifth course above the ground, and is the sixth one from the southwest corner of the building.

XXV.—At Pinson, Madison County, Tenn. The center of a cross cut in a brass bolt leaded horizontally into a brick in the front of M. M. Robin's store. The house is west and a short distance north of the railroad station, facing the track. The brick is in the eleventh course above the sidewalk, and is the second one from the northeast corner of the building.

XXIV.—About $2\frac{1}{2}$ miles south of Jackson, Tenn. The bottom of a square cavity cut in the stone coping of the brick pier at the north end of the Mobile and Ohio Railroad bridge over Forked Deer River. The mark is west of the track near the lower chord of bridge, and about 13 inches from the north edge of stone.

XXIII.—At Jackson, Tenn. The bottom of a square cavity cut in the capstone of the retaining wall in front of one of the basement windows of the Federal Building, corner of Market and Baltimore streets. The window is just north of the Market-street entrance. The stone is marked thus:

U. S.

□

B. M.

XXII.—At Jackson, Tenn. The bottom of a square cavity cut in the capstone of the brick pier at the west end of the Illinois Central Railroad bridge over Market street. It is south of the track, and marked thus:

U. S.

□

B. M.

XXI.—At Oakfield, Madison County, Tenn. The bottom of a square cavity cut in a limestone block set in the southwest corner of the front yard of R. Daniel's house, which stands just north of the store and post-office. The block is 6 inches square, projects 6 inches from the ground, and is marked thus:

U. S.

□

B. M.

XX.—At Medina, Gibson County, Tenn. The bottom of a square cavity cut in a limestone block set in the northwest corner of W. A. House's front yard. The block is 6 inches square, projects 6 inches from the ground, and is marked thus:

U. S.

□

B. M.

XIX.—At Milan, Gibson County, Tenn. The bottom of a square cavity cut in a limestone block set in the front yard of Dr. M. D. L. Gordon's house, on Main street, near the public school. The stone is north of the house, near the back fence. It is 6 inches square, and marked thus:

U. S.

□

B. M.

XVIII.—At Milan, Tenn. The center of a cross cut on a brass bolt leaded horizontally into a brick, in the north wall of the building on the southwest corner of Front and Main streets. The brick is in the seventh course above the pavement, and is the sixth one east of the second doorway from the west end of the building.

XVII.—At Bradford, Gibson County, Tenn. The bottom of a square cavity cut in a granite block set in the southwest corner of the front yard of J. T. Cain's house, which stands southeast of the railroad station, fronting on the track. The stone is 6 inches square, projects 6 inches from the ground, and is marked thus:

U. S.

□

B. M.

XVI.—Near Greenfield, Tenn. Found unstable, abandoned.

XV.—At Greenfield, Tenn. A small hole in a brass bolt leaded horizontally into a brick in the front wall of Darling Jones' storehouse. The brick is in the eighth course above the pavement, and is the third one from the northwest corner of the building.

SECTION II.—*Location and description of permanent bench marks between Greenfield, Tenn., and Villa Ridge, Ill.*

XV.—At Greenfield, Tenn. Described in Section I.

XIV.—At Sharon, Weakly County, Tenn. The center of a cross cut in a brass bolt leaded horizontally into a brick in the chimney at the north end of Lloyd Dodd's house. The brick is in the twenty-fourth course above the ground, near the middle of the chimney. The mark is roughly lettered thus:

U. S.

B. M.

XIII.—At Martin, Weakly County, Tenn. A small hole in a brass bolt leaded horizontally into a brick in the west side of the bank building owned by J. R. Lovelace. The brick is in the tenth course above the ground, and is the fourth one from the north-west corner.

XII.—At McConnell, Obion County, Tenn. The bottom of a square hole cut in a limestone block set in the northeast corner of the yard of W. B. Smith, agent for the Illinois Central Railroad. The block is 6 inches square, projects 4 inches above the ground, and is lettered thus:

U. S.

□

B. M.

XI.—At Fulton, Fulton County, Ky. A hole in a brass bolt leaded horizontally into a brick in the east wall of E. C. Reed's livery stable. The brick is in the nineteenth course from the ground, and is the fifteenth one from the northeast corner of the stable. The wall is marked thus:

U. S.

•

B. M.

X.—At Alexander, Fulton County, Ky. The bottom of a square cavity cut in a limestone block set near the northwest corner of J. M. Cashon's frame house, on the east side of the railroad track, near the station. The block is 6 inches square, projects 4 inches from the ground, and is lettered thus:

U. S.

□

B. M.

IX.—At Clinton, Hickman County, Ky. The bottom of a square cavity cut in the stone doorsill at the south entrance of the courthouse. It is lettered thus:

U. S.

□

B. M.

VIII.—At Arlington, Carlisle County, Ky. The bottom of a square cavity cut in a limestone block set in the southwest corner of the back yard of Thos. G. Edward's house, near the railroad station. The block is 6 inches square, projects 4 inches from the ground, and is lettered thus:

U. S.

□

B. M.

VII.—At Bardwell, Carlisle County, Ky. The bottom of a square cavity cut in the south end of the stone doorsill at the west entrance to the court-house. It is marked thus:

U. S.

□

B. M.

VI.—On the Illinois Central Railroad bridge over Mayfield Creek, which is the boundary between Ballard and Carlisle counties, Ky. The bottom of a square cavity cut on the stone coping of the brick pier on the north bank of creek. It is west of the track, just outside of the bridge, and lettered thus:

U. S.

□

B. M.

V.—At Fort Jefferson, Ballard County, Ky. The bottom of a square cavity cut in a limestone block set in the northeast corner of J. M. Vance's yard, across the street from J. C. Depoyster's store. The block is 6 inches square, projects 4 inches from the ground, and is lettered thus:

U. S.

□

B. M.

IV.—At Wickliffe, Ballard County, Ky. The bottom of a square cavity cut in a limestone block set near the northwest corner of the Elliott House, close to the brick wall on the street. The block is 6 inches square, projects 3 inches from the ground, and is lettered thus:

U. S.

□

B. M.

III.—At East Cairo, Ballard County, Ky. The bottom of a square cavity cut in a limestone block set in the top of the levee protecting the Mobile and Ohio Railroad yard, just back of the yardmaster's office. The block is 6 inches square, projects 2 inches from the ground, and is lettered thus:

U. S.

C. □ S.

B. M.

U. S. E. 3.—At Cairo, Ill. Established by the U. S. Engineers, and described by the Miss. River Comm. as follows: "Is hole in copper bolt set in southeast end of Illinois Central Railroad freight depot, at junction of Fourteenth street and Ohio River. It is 0.49 metres southwest of the east corner and is marked with the letters U. S. B. M. cut in stone near bolt." When visited in 1888 some of the lead had been picked from around the bolt, but the bolt was still firm. The arches of the building were cracked, as if it had settled.

U. S. E. 2.—At Cairo, Ill. Established by the U. S. Engineers and described by the Miss. River Comm. as follows: "Is hole in copper bolt set horizontally in east side of building containing offices of the trustees of Cairo City public property. It is 4.44 metres from southeast corner, and 1.12 metres below lower surface of water table. Marked with the letters U. S. B. M. cut in stone near bolt. The building fronts on Washington avenue and is between Eighteenth and Nineteenth streets." The mark was found undisturbed in 1888.

U. S. E. 1.—At Cairo, Ill. Established by the U. S. Engineers and described by the Miss. River Comm. as follows: "Is small hole in center of copper bolt set horizontally in northwest side of custom-house. It is 7.18 metres from northwest corner and 0.37 metres below the junction of the sandstone and limestone, and 0.93 metres above surface of cement walk. Marked with the letters U. S. B. M. cut in stone near bolt. The custom-house is in the square bounded by Fourteenth and Fifteenth and Poplar streets and Washington avenue." It was found undisturbed in 1888.

II.—On one of the abutments of the Illinois Central Railroad bridge over Cash creek. The bottom of a square cavity cut in the abutment at the south bank of the creek, on the east side of the track, and marked thus:

U. S.

□

B. M.

I.—At Mound City Junction, Alexander County, Ill. The bottom of a square cavity cut in a limestone block set in the yard of the Illinois Central Railroad section house. It is near the front fence just north of the gate, near lone tree. The stone is 6 inches square, projects 4 inches from the ground and is lettered thus:

U. S.

□

B. M.

Z₃.—At Villa Ridge, Pulaski County, Ill. The center of a brass bolt leaded horizontally into a brick in the chimney at the east end of the Stoddard House. The brick is in the twenty-second course above the ground and is the fifth one from the south end of chimney.

Y₃.—At Villa Ridge, Ill. Top of a railroad spike driven in the root on the east side of a large beech tree which stands east of the railroad track and nearly opposite the 12-mile post. It is lettered thus:

(U. S. B. M.
"Y")

SECTION III.—*Location and description of permanent bench marks between Villa Ridge and Odin, Ill.*

Z₃.—At Villa Ridge, Pulaski County, Ill., described in Section II.

Y₃.—At Villa Ridge, Ill., described in Section II.

XII_a.—South of the 14-mile post on the Illinois Central Railroad. The bottom of a square cavity cut near the center of south abutment of small railroad bridge No. 8, marked thus:

□

139.—About 523 metres south of the 17-mile post on the Illinois Central Railroad. The bottom of a square cavity cut in the capstone of the middle pier of small railroad bridge, No. 12. It is east of the track and is marked thus:

(□)

X₃.—Near Ullin Station, Pulaski County, Ill. The bottom of a square cavity cut on the northeast corner of the north abutment of bridge No. 15, over the Cache River. It is marked thus:

□
U. S.
B. M.

W₃.—At Anna, Union County, Ill. The bottom of a square cavity cut in the stone sill of window on southwest front of Otrich's drug store, under the Otrich House. It is about 0.10^m from west end of iron jamb and 0.06^m from south edge of sill. It is marked thus:

(□)

V₃.—About 1 mile north of Makanda, Jackson County, Ill., and 50 metres south of the 50-mile post on the Illinois Central Railroad. The bottom of a square cavity cut in the southeast capstone of south abutment of iron bridge No. 87, over Drury Creek. It is marked thus:

(□)

T₃.—At Carbondale, Jackson County, Ill. The bottom of a square cavity cut in the stone sill under the east front window of Jacob Beard's brick store. The store is on the west side of the railroad track at the north end of public park. The cavity is marked thus:

(□)

U₃.—In Jackson County, Ill., about 2 miles south of De Soto. The bottom of a square cavity cut in the west end of the south abutment of Illinois Central Railroad bridge over Big Muddy Creek. It is about one metre west of track and 0.3^m from north edge of abutment, and is marked thus:

(□)

R₃.—At Duquoin, Perry County, Ill. The bottom of a square cavity cut in corner of the stone sill at the main door of the Du Quoin bank building, opposite the Illinois Central Railroad depot. The cavity is marked thus:

(□)

S₃.—About 2 miles south of Radom Station, Washington County, Ill. The bottom of a square cavity cut in the northeast corner of the north abutment of the stone-arch bridge, over Little Muddy Creek, on the Illinois Central Railroad. It is marked thus:

(□)

Q₃.—Near Ashley, Washington County, Ill. The bottom of a square cavity cut in the capstone of the southeast wing wall of small culvert, No. 212, on the Illinois Central Railroad, about 175 metres south of the 99-mile post. The cavity is about 2 metres east of the track, and is marked thus:

(□)

P₃.—About 1 mile north of Richview Station, Washington County, Ill. The bottom of a square cavity cut in the southeast corner of the capstone on the east end of a stone culvert on the Illinois Central Railroad, 409 metres south of the 103-mile post. The cavity is marked thus:

(□)

N₃.—At Centralia, Marion County, Ill. The bottom of a square cavity cut in the stone sill of the south window of J. J. Pfaff & Co.'s drug store, marked thus:

(□)

O₃.—About 2 miles north of Centralia, Ill. The bottom of a square cavity cut in the capstone at the east end of the north abutment of the Illinois Central Railroad bridge over Crooked Creek. The cavity is about 3 metres from the iron foot-plate of bridge, and is marked thus:

(□)

M₃.—At Odin, Marion County, Ill. The bottom of a square cavity cut in a rock in the top layer of the foundation, at the southeast corner of Craig's brick store. It is about 1 foot above the ground, and is marked thus:

(□)

V.—At Odin, Ill. The bottom of a square cavity cut in the southeast end of a long arched culvert on the Ohio and Mississippi Railroad, about 45 metres east of the junction of that road and the Illinois Central Railroad.* This bench is the intersection of the trans-continental line of levels and the line from the Gulf of Mexico. It is marked thus:

(B. M. "V.")
□

*This bench mark V was established by Assistant A. Braid in 1882. See Appendix No. 11, U. S. C. and G. Survey Report for 1882.

